

ams analyst and investor day 2017

Shaping the world with sensor solutions

Singapore | December 2017



Analyst and investor day 2017

Agenda

Time	Topic	Presenter
11:00 – 11:05	Welcome	Moritz Gmeiner - VP Investor Relations
11:05 – 11:30	Company strategy	Alexander Everke - CEO
11:30 – 12:00	3D sensing	Ulrich Huewels - EVP & GM Division Optical Sensor Solutions
12:00 – 12:20	Light & spectral sensing	Jennifer Zhao - EVP & GM Division Advanced Optical Sensors
12:20 – 12:40	Image sensing	Stéphane Curral - SVP & GM Division Image Sensor Solutions
12:40 – 13:10	Q&A	
13:10 – 14:00	Lunch	
14:00 – 14:20	Environmental and audio sensing	Mark Hamersma - EVP & GM Division Environmental & Audio Sensors
14:20 – 14:40	Next frontier sensing applications	Thomas Stockmeier - COO
14:40 – 14:50	Manufacturing strategy	Mike Lusk - EVP Operations & Supply Chain Management
14:50 – 15:10	Financial performance & outlook	Michael Wachslers-Markowitsch - CFO
15:10 – 15:30	Q&A	
15:30 – 15:35	Closing remarks	Alexander Everke - CEO
15:35 – 16:00	Coffee	
16:00 – 16:30	Transfer to site visit	For participants

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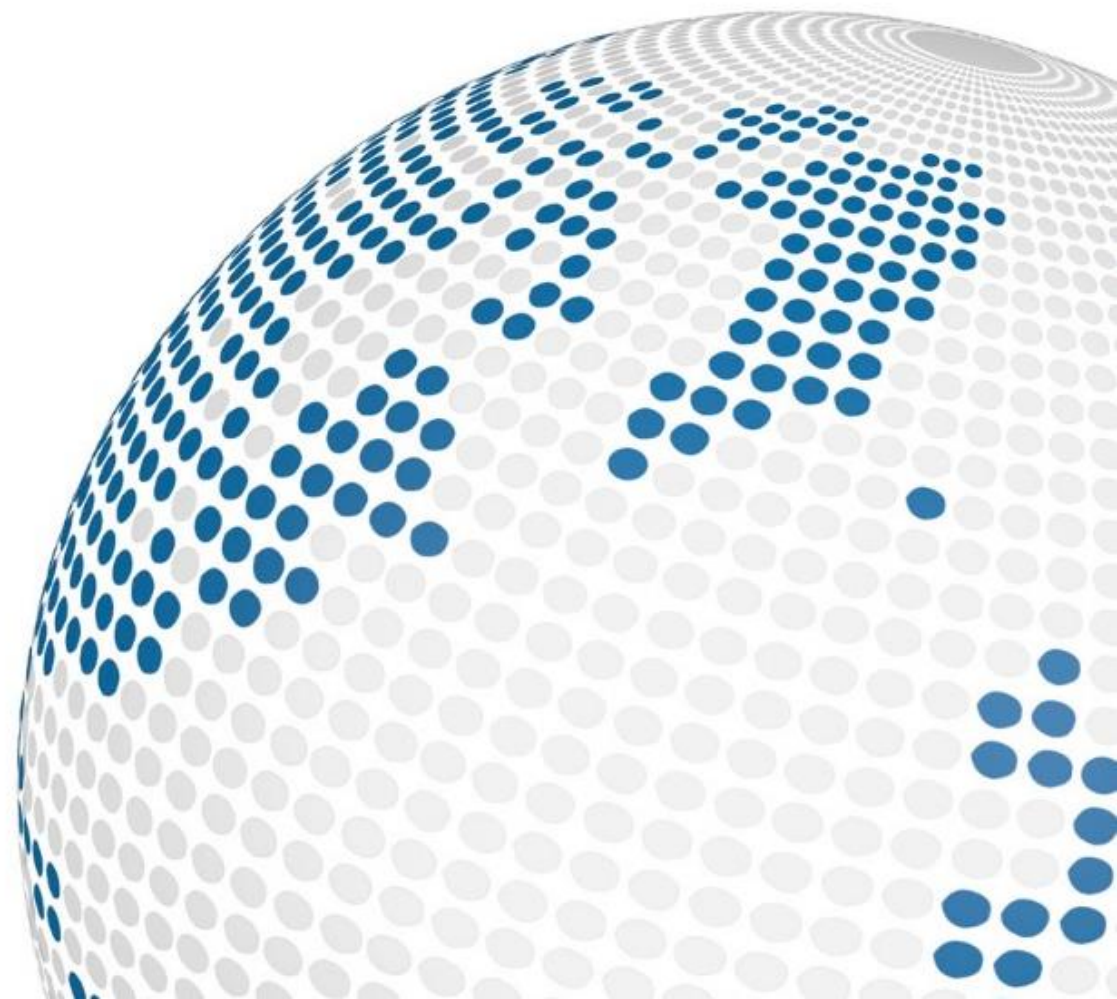
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Company strategy

Alexander Everke
Chief Executive Officer



ams at a glance



Our business

- Focused on high-performance sensor solutions
- Sensor solutions, sensor ICs, interfaces, related software
- Small, low-power, highest sensitivity, multi-sensor integration
- Best-in-class solutions for leading OEMs

Our end markets

- Consumer & Communications (C&C)
- Automotive, Industrial, Medical (AIM)



By the numbers

- 1,000+ engineers
- 21 design centers, 3 manufacturing locations
- 35+ years of design and manufacturing know-how
- 10,000+ employees worldwide
- 8,000+ customers

Digital transformation fuels growth sensor markets

Megatrends drive sensor markets



Build the global leader in sensor solutions

True leadership in four sensor areas

- Optical
- Imaging
- Environmental
- Audio sensing

Best-in-class performance per sensor area and in multi-sensor application solutions

- Miniaturization & Integration
 - Multi-sensor modules
 - Monolithic integration
- Sensor algorithms and sensor fusion software
- Application software for differentiating end-user experiences

Diversified business with balanced application and customer portfolio

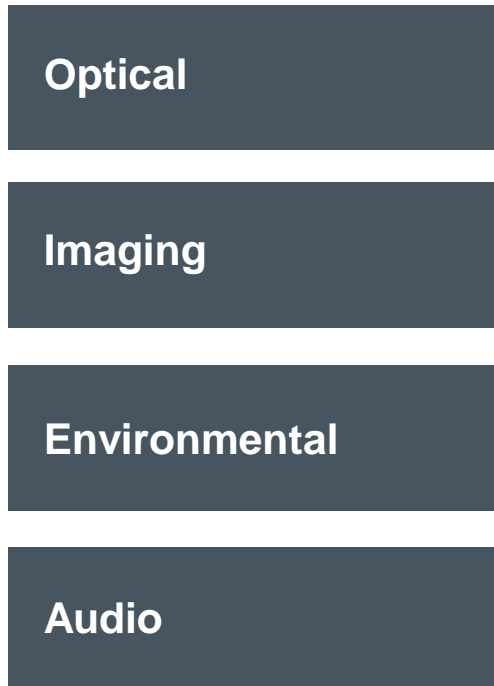
- Long-term target mix of 60/40 split C&C/AIM
- Build broader customer base in each application
- Establish strong distribution channel

Clear financial target model

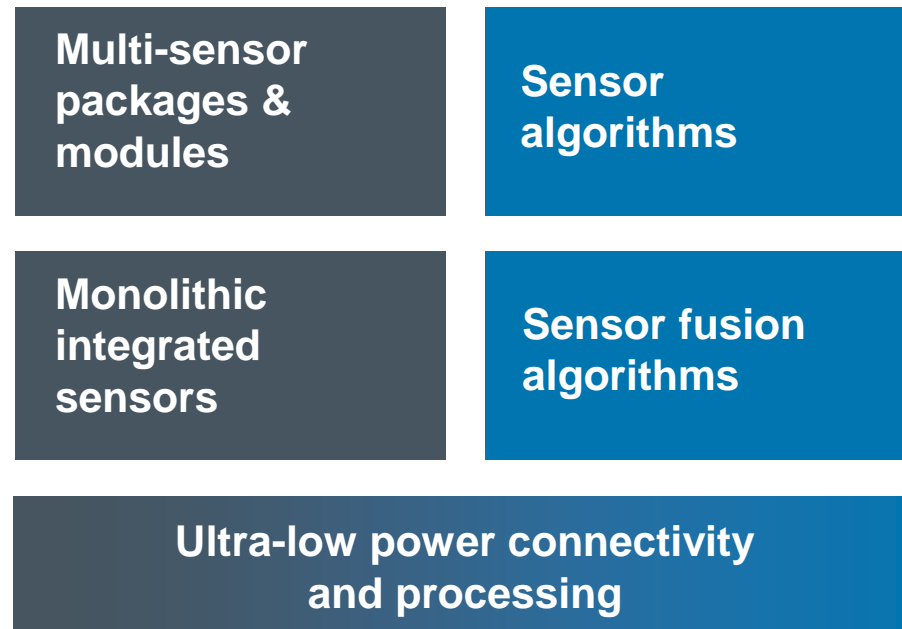
- Revenues growth target (CAGR) 2016-2019 of more than 40%
- EBIT margin target (adjusted) of 30% from 2019

ams strategic value chain

Sensor ICs



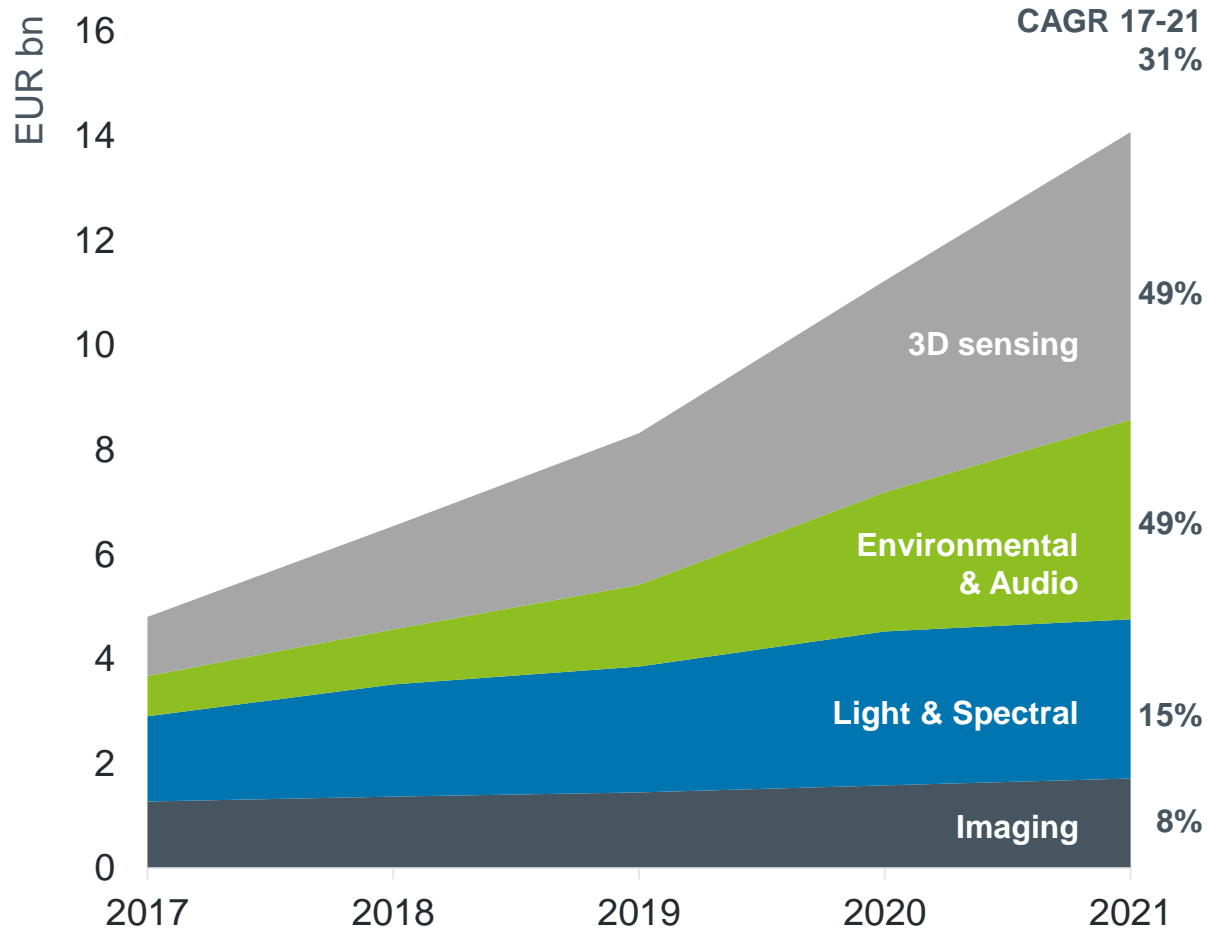
Sensor solutions



Application solutions



ams major growth markets



Inflection after 2019

3D sensing market will grow 7 times the market of today in just 5 years time

Environmental & Audio sensing market is driven by compelling growth in gas, humidity and particle sensor as well as double-digit growth in audio market

Light and spectral sensing market shows 15% growth, not including emerging opportunities

Image sensing shows solid growth driven by machine vision and medical healthcare diagnostics

Multiple continuous growth vectors

					4 sensor pillars relevance			
					Optical	Imaging	Environm.	Audio
3D	Mobile	Smart home	Wearables	Automotive	✓	✓		
Light & Spectral	Paper like display	Color matching		Food analysis	✓	✓	✓	
Imaging	Machine vision	Always-on vision		Convergence with spectral sensing	✓	✓		
Environmental	Smart home assist	Convergence audio-environmental		Mobile air quality/gas	✓	✓	✓	✓
New horizons	Biosensing	Electronic nose		Spectrometer on a chip	✓	✓	✓	✓
time								

Exciting opportunities in 3D/spectral sensing

Supporting a vast array of applications and use cases

Mobile/Computing



- Face recognition
- Augmented/Mixed Reality
- Morphing/Avatars
- Gesture recognition
- Color matching
- Food analysis

Industrial



- 3D position sensing
- Autonomous robots
- Pattern recognition
- Hyper-Spectral Imaging (HSI)

Smart Home/IoT



- Presence detection and personalization
- Gesture recognition
- Smart lighting

Automotive



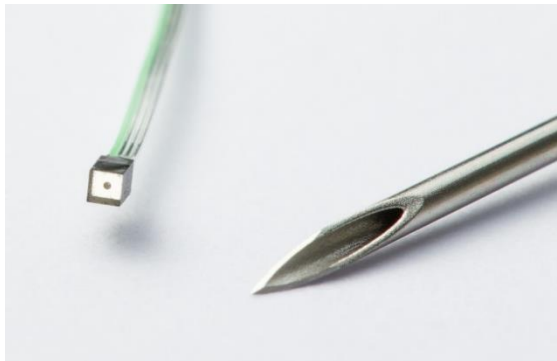
- Driver authentication
- Driver monitoring
- Smart gestures
- 3D LIDAR

Driving market share gains

Differentiation, convergence trends and solution play drive market share

Differentiation by performance

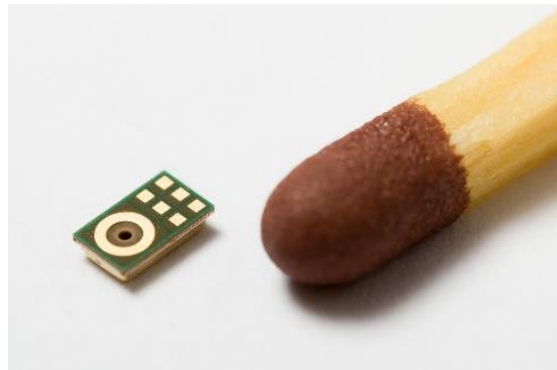
- Small form factor, low power, highest sensitivity
- Unique technology, e.g. in interferometric filter capabilities and micro-optic packaging



NanEye size

Convergence play

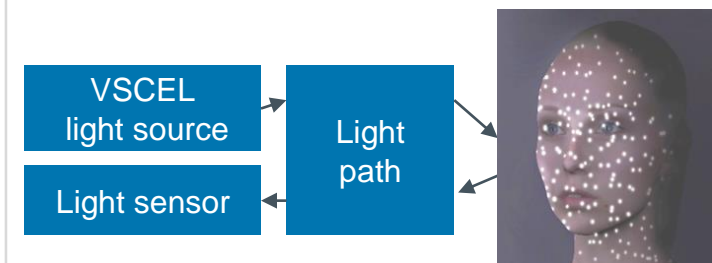
- Increase value by integrating various sensor modalities



Microphone + temperature + pressure

Solution play

- Increase value by offering full solutions including software



Focused M&A accelerates strategy

2014/2015

Acquisition of **acam**
(time-to-digital conversion)

Acquisition of **NXP monolithic environmental CMOS sensors**

Acquisition of **CMOSIS**
(CMOS image sensors)

2016

Acquisition of **CCMOSS**
(gas and infrared sensors)

Acquisition of **MAZeT**
(spectral sensing)

Acquisition of **Incus**
(ANC IP portfolio)

Divestment of **NFC and RFID reader business**

2017

Acquisition of **Heptagon**
(high-end optical system technologies and manufacturing)

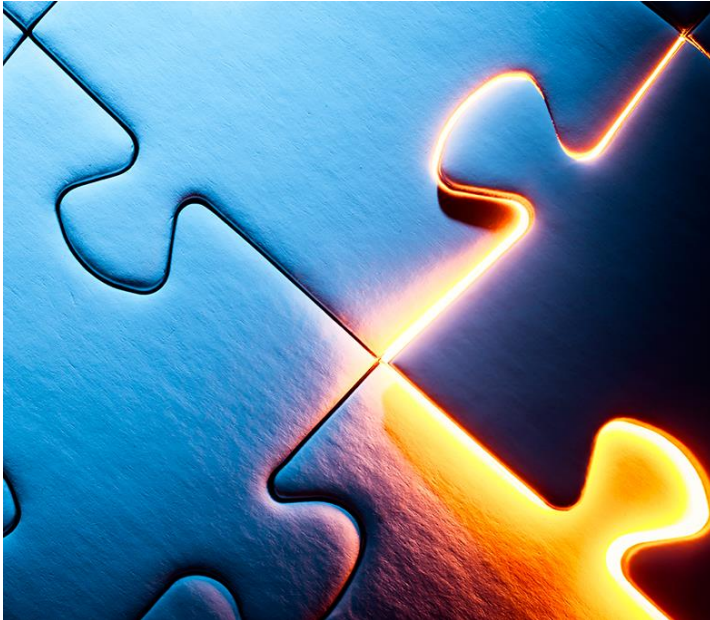
Acquisition of **Princeton Optronics** (high power VCSEL)

Foundation of **7SensingSW**
(sensing software company)

Partnership with **Sunny Optical**
(modules for 3D sensing)

Divestment of **backlight LED display driver business**

Based on clear M&A principles



Buy technology, not revenues to build leadership positions

Enable full application solutions to increase differentiation

Strengthen specific areas of need such as software development, market access

Add long-term strategic value

Winning portfolio

True leadership in four sensor areas

Other



Optical Sensors

- 3D sensing
- Light analysis
- Spectral sensing
- Proximity

Imaging Sensors

- 2/3D Imaging
 - Area/Line Scan
 - Micro Camera
 - NIR sensors

Env. Sensors

- Gas
- RH/T
- Pressure
- Particle

Audio Sensors

- MEMS MIC ICs
- ANC
- ACI

Other sensors

- Position sensors
- Ultrasonic flow metering
- ULP wireless sensors

M&A accelerating implementation

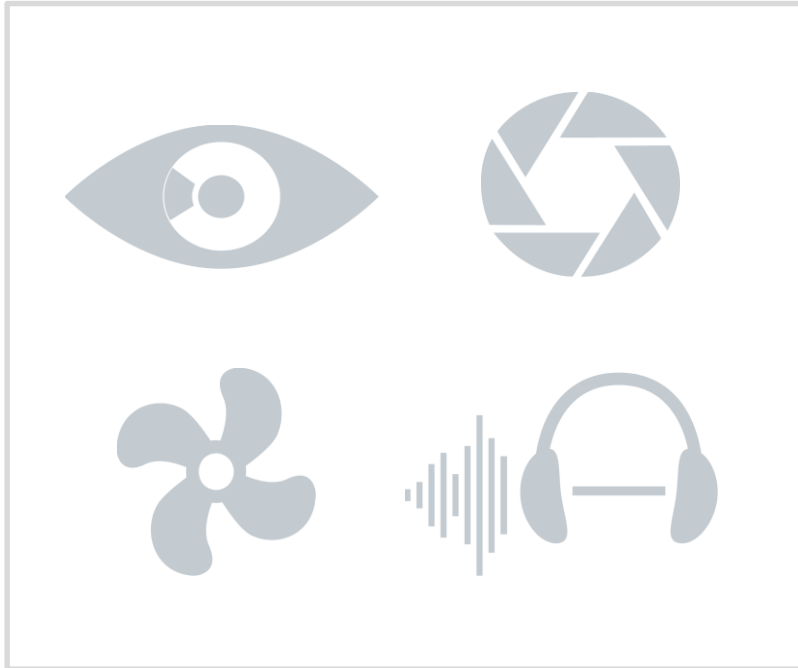
- Heptagon
- Princeton Optronics
- Mazet

- CMOSIS
- Heptagon

- CCMOSS
- NXP sensors

- Incus

Four strategic pillars already >80% of revenues



**>80% revenues 2017E already in 4 strategic pillars,
expected to grow to above 90% in 2020**

R&D investments clearly shifted and optimized to fit four pillar strategy

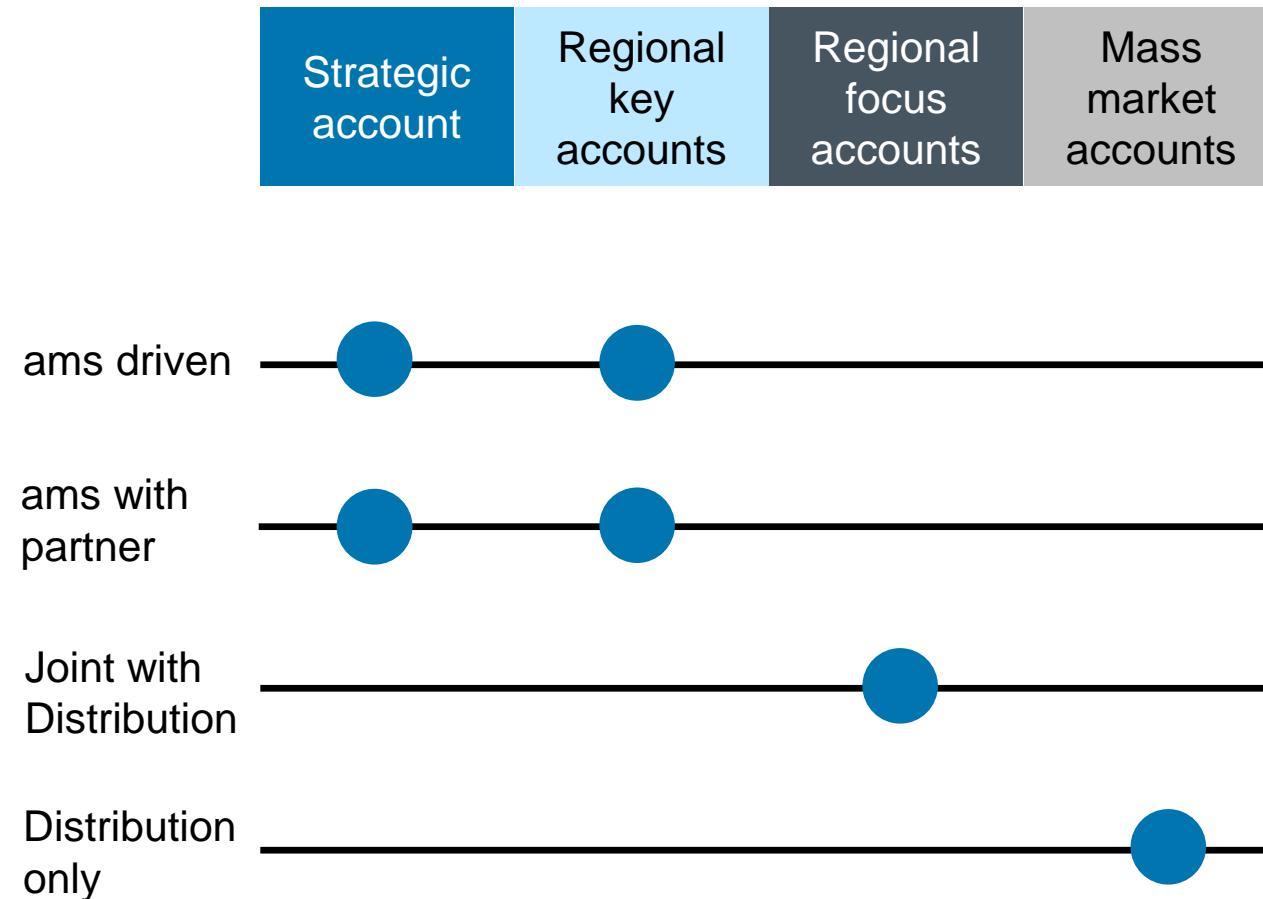
Major investments into strategic platforms

Short term growth driven by mobile, mid term stronger contribution from Automotive, Industrial and Medical

Expected revenue growth of 40%+ CAGR 2016-2019

World class organization and “go to market”

Focusing on the growth opportunities



Focused ams sales team

- Investing in China growth, expand local presence including technical support
- Focusing on larger accounts
- In consumer, targeting both iOS and Android ecosystems
- Close strategic partnerships with leaders in solutions value chain, e.g. Sunny Optical
- Strengthen partnerships with selected distributors to address regional focus accounts and the long tail of smaller accounts

Successful execution of our strategy



Delivering ahead of commitment, increasing ambition

2016:

- Revenue growth target 2016-2019 set at 30%+ CAGR
- EBIT margin target (adj.) of 30% from 2019

2017:

- Revenue growth target 2016-2019 increased to 40%+ CAGR
- EBIT margin target (adj.) of 30% from 2019
- Expected 2017 revenues of more than 1bn EUR

Key takeaways



Building the global leader in sensor solutions

- Addressing megatrends driving above market growth
- Active portfolio management: both organic and in-organic, today and in the future
- Driving market share gains: differentiate by performance, convergence trends and solution play
- Building a world class team to execute to win

Our team



Alexander Everke
CEO
ams, NXP, Infineon
26 yrs industry experience



Michael Wachslar
CFO
ams, AC, Ericsson, KPMG
16 yrs industry experience



Thomas Stockmeier
COO
ams, SEMIKRON, ABB
32 yrs industry experience



Mike Lusk
EVP Operations & Supply Chain
ams, NXP, Freescale, Motorola
42 yrs industry experience



Verena Vescoli
SVP R&D
ams, AVL
17 yrs industry experience



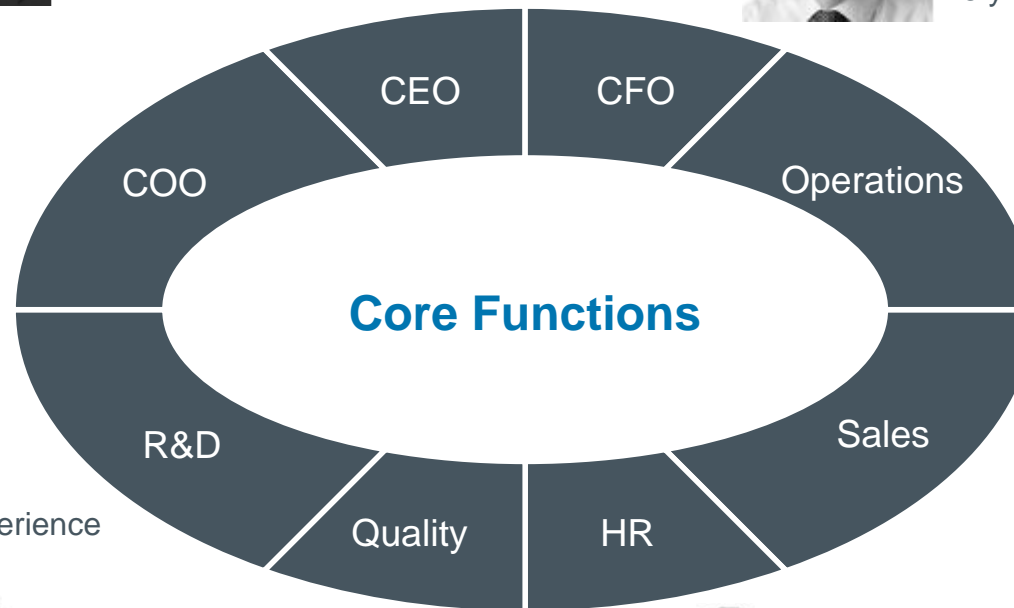
Pierre Labois
EVP Sales
ams, Asteel, NXP, Infineon
22 yrs industry experience



Herwig Klimesch
SVP Quality
ams, AVL
22 yrs industry experience



Peter Kleij
SVP HR
ams, Mediq, NXP, Philips, AT&T
39 yrs industry experience



Our team



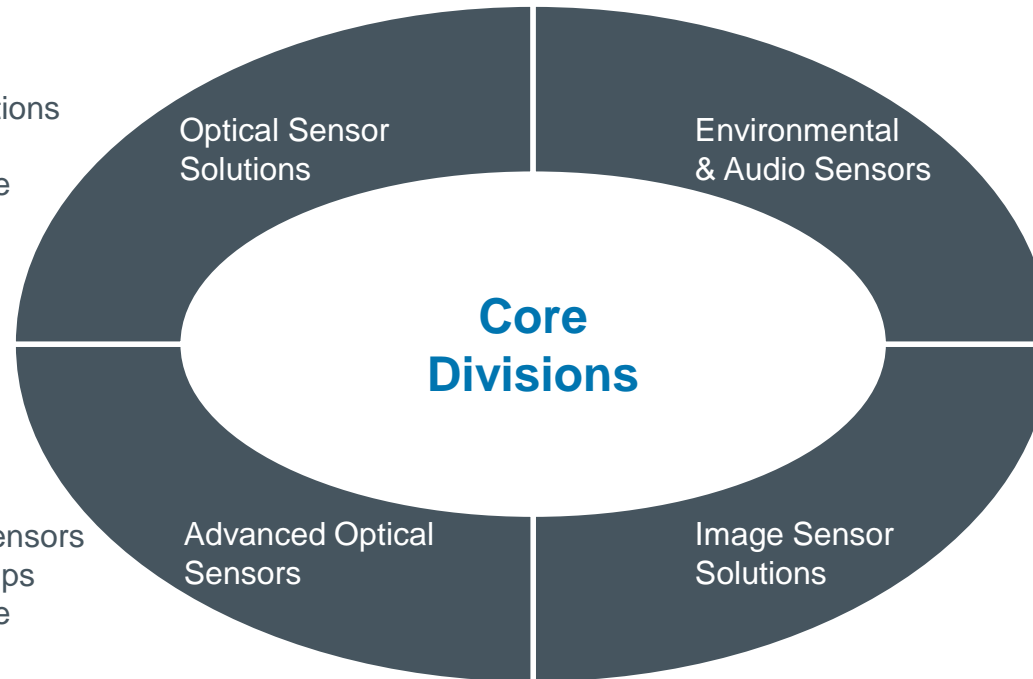
Ulrich Huewels

EVP Optical Sensor Solutions
ams, NXP, Intel, Infineon
27 yrs industry experience



Jennifer Zhao

EVP Advanced Optical Sensors
ams, Nexperia, NXP, Philips
17 yrs industry experience



Mark Hamersma

EVP Environmental & Audio Sensors
ams, NXP, Philips, McKinsey
20 yrs industry experience

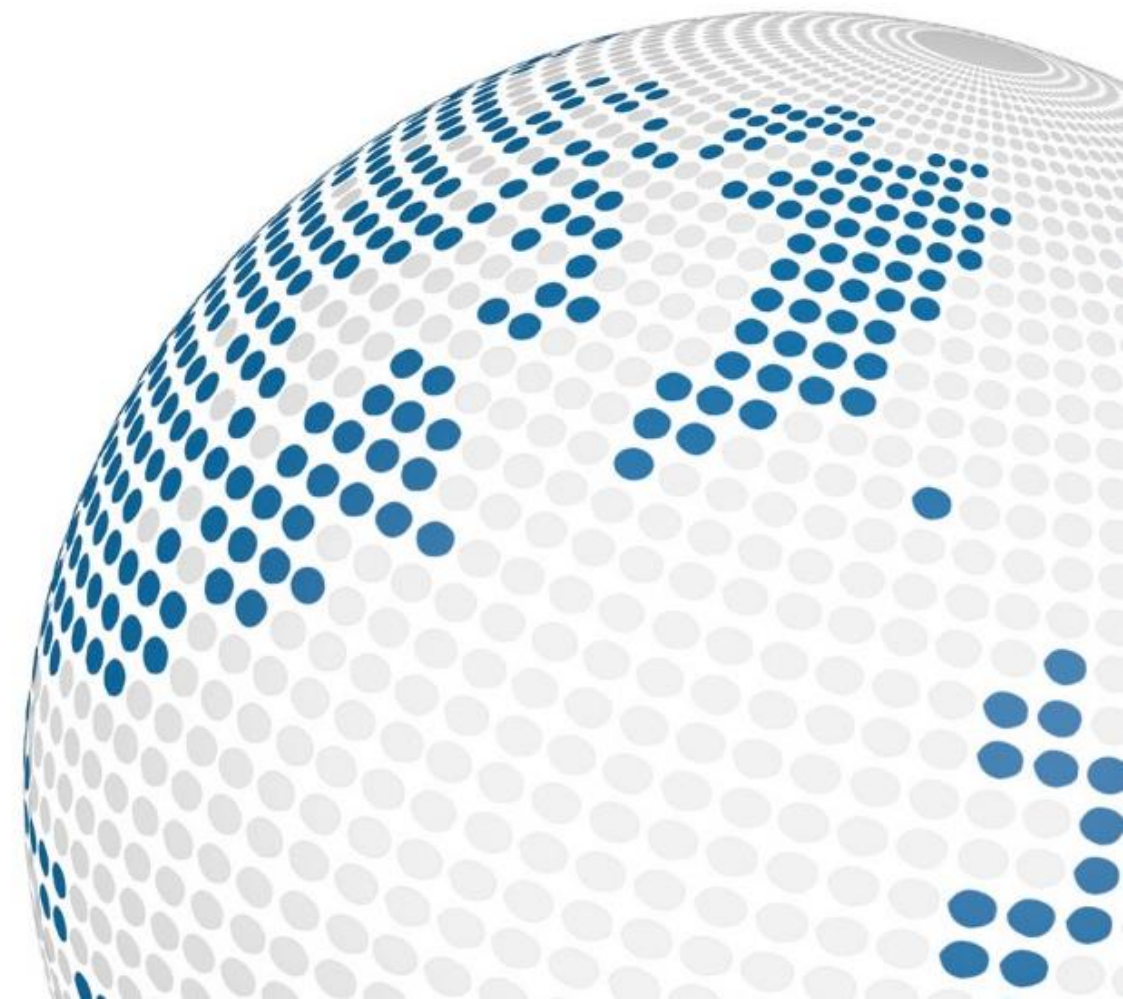


Stephane Curral

SVP Image Sensor Solutions
ams, NXP, Philips
24yrs industry experience

3D sensing

Ulrich Huewels
Executive Vice President & General Manager
Division Optical Sensor Solutions



3D sensing

Imagine the impossible

Mobile

- Biometric authentication
- Augmented reality
- Background removal
- Personalized avatars/emoticons
- Gesture control



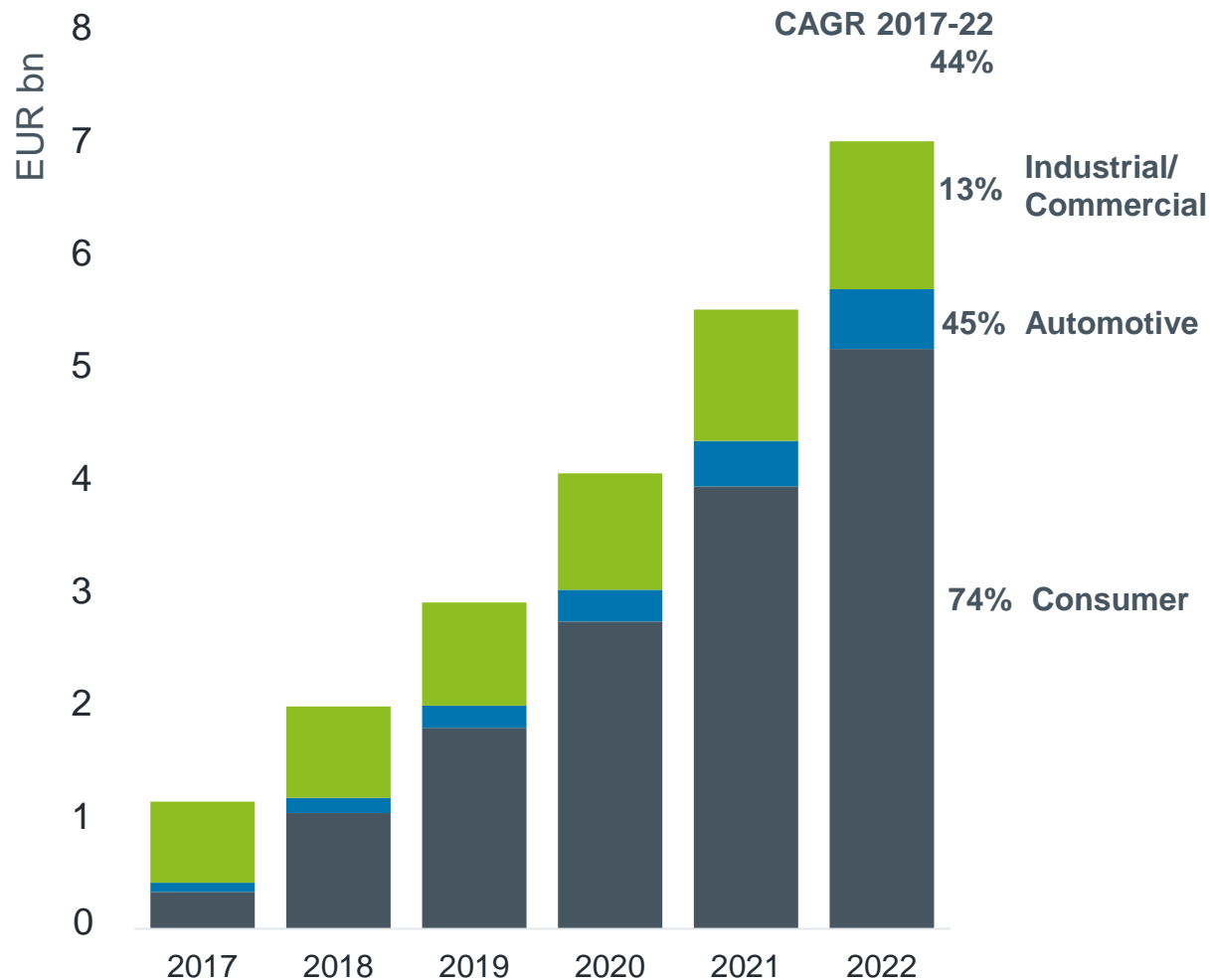
Expanding applications

- Automotive: autonomous driving and driver recognition
- Industrial: inspection, robots, drones
- Home: gesture control
- Medical: 3D endoscopy



3D sensing market

Market will be 7x today's market in 5 years



Source: ams market model and external reports
Scientific/defense/space and medical applications are not included

Progress in optical modules driving mass adaption of 3D sensing in the consumer market

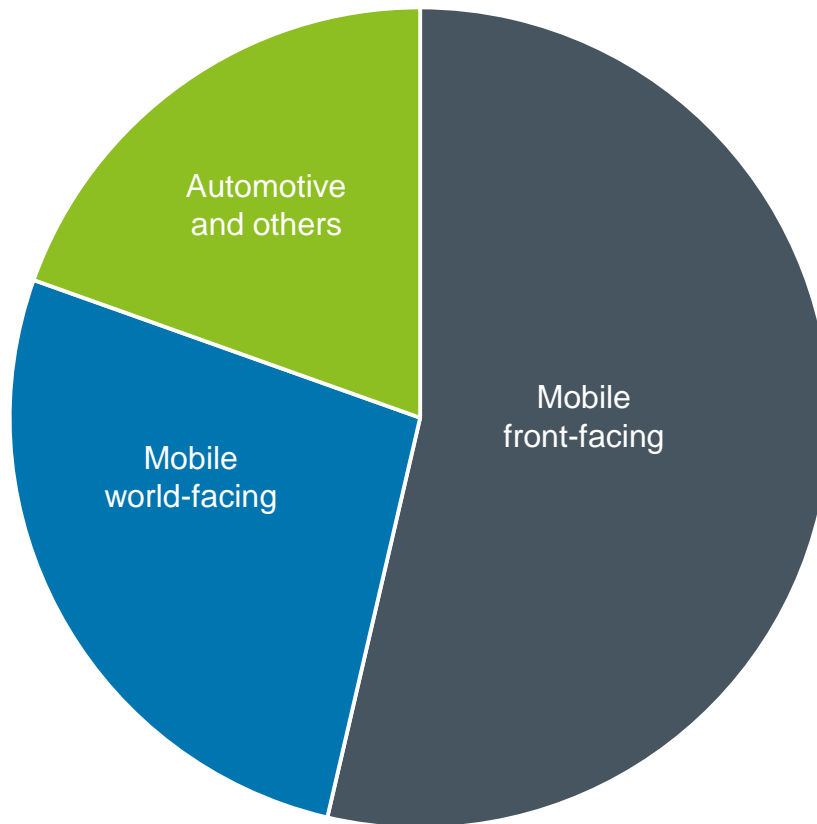
- 74% CAGR in consumer applications (2017-22)
- ams sees even stronger traction in consumer applications already in 2017/18

Exciting new applications:

- 3D will proliferate beyond mobile to computing, wearables, automotive and home assistance
- Automotive: solid growth expected until 2022 (45% CAGR 2017-22), expected acceleration beyond 2022 due to adoption of Driver Assistance Systems (ADAS) and Autonomous Driving

Technology mapping and total available market

3D Sensing market 2021



Others include tablets and laptops, smart home, robotics & drones, AR/VR
Source: ams market model and external reports

Application focus on Mobile and Automotive Technology focus on Structured light and Time-of-Flight (ToF)

ams is focusing on mobile applications

- Front-facing
- World-facing

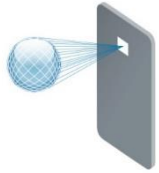
Structured light & ToF allow to cover the majority of applications in consumer / mobile market

Automotive will include 3D LIDAR (Light Detection And Ranging) and in-cabin applications such as driver authentication, monitoring and gesture control

Smart home, Augmented Reality, robotics/drones will be a highly segmented market with a broad range of products

Structured Light and Time-of-Flight (ToF)

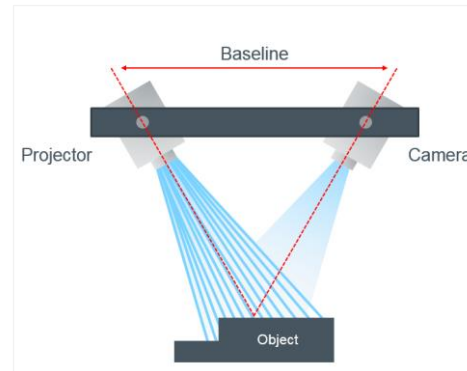
Principles of operation



Structured Light

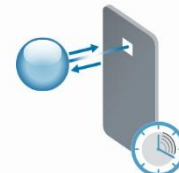
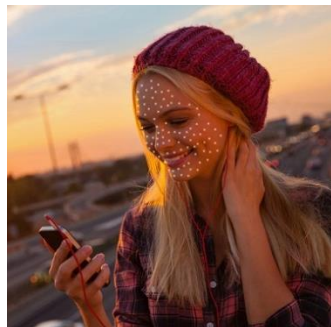
Principle:

- A known pattern is projected onto an object
- The pattern is distorted when the light hits the object
- By analyzing the deformation of the known pattern, depth can be calculated by triangulation



Hardware:

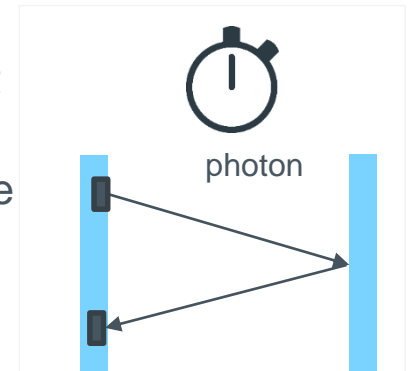
- Pattern projector: coded/random pattern of 30+k dots
- IR camera for pattern imaging



Time-of-Flight

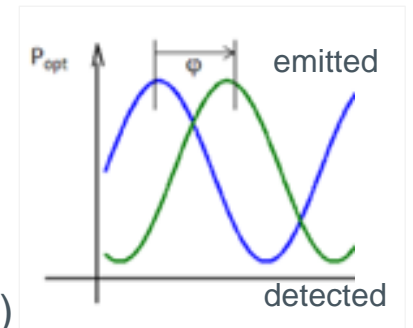
Principle:

- Sending out an infrared signal (short pulse or sinusoidal modulated wave)
- Measuring time (direct-ToF) or phase (indirect-ToF) between emission and detection of reflected signal

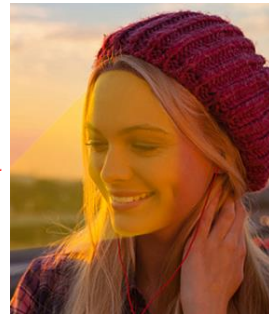
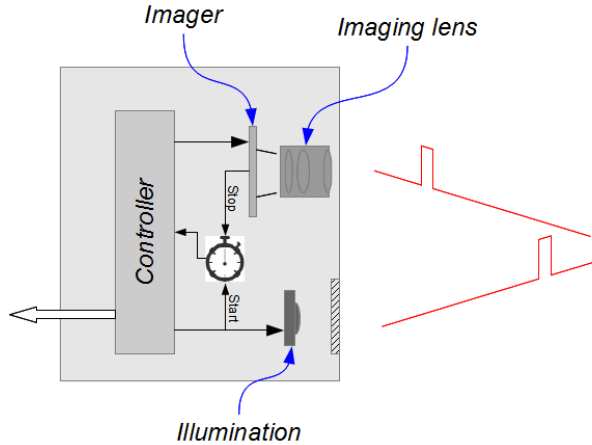


Hardware:

- Infrared illumination: short pulses or modulated light
- ToF pixel array: customized CMOS sensors (high speed, high sensitivity)



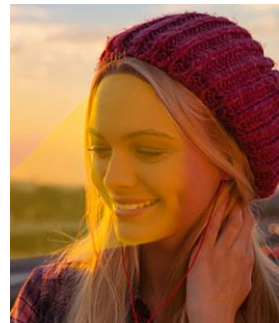
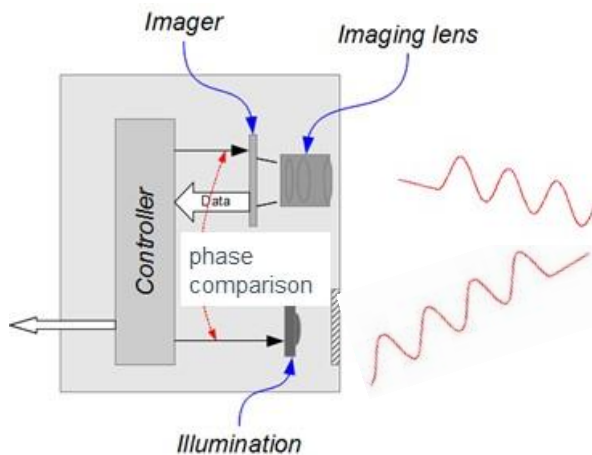
Two ToF technologies: direct/indirect



Direct Time-of-Flight (dToF)

- Measure the direct time-of-flight, “stop watch” approach: send out short pulses of light, measure time until echo hits sensor using SPAD detection
- VCSEL output pulse length: 0.2 nsec - 5 nsec; the shorter the better (resolution, eye safety)
- Very accurate with multiple objects, immune to smudges on cover glass
- Limited to a small number of sensor elements

Best solution for single/few points ranging (range finder)



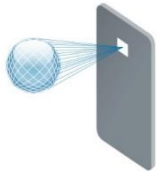
Indirect Time-of-Flight (iToF)

- Measurement of phase shift: illumination with intensity-modulated light, phase shift is proportional to distance
- VCSEL output: 20-100MHz modulated sine wave
- Very small pixel, standard CMOS technology, enables high pixel count (QQVGA-VGA)

Best solution for 3D imaging

Structured light and time-of-flight (ToF)

Advantages and challenges

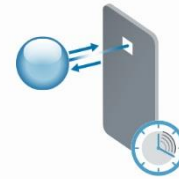


Structured light

- + High accuracy: dense dot patterns and a reasonable base line lead to high x/y/z resolution
- + No artefacts: triangulation is very stable under most typical use cases
- Form factor: needs stable base line with accurately assembled components
- High processing requirement: highly parallel processing for depth calculation needed

Best suited for

- High resolution 3D sensing: lowest power, highest accuracy and stability



Time-of-flight

- + No base line: no need for mechanical calibration and stable set-up
- + Low processing requirement: all done in or close to pixel
- + "True measurement": independent of target size, color and reflectance
- Power hungry illumination: high accuracy needs high optical power
- Artefacts: reflections, scattering

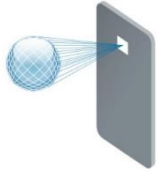
Best suited for

- Range finders: direct ToF with SPAD receivers
- Basic 3D imaging with medium pixel count

Critical system issues like eye safety need to be addressed comprehensively, increasing importance for world facing due to higher range

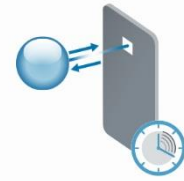
ams 3D mobile solutions

Structured Light and ToF use cases



Structured Light

- miniature projection system
- high resolution dot pattern
- highest performance



Time-of-Flight

- compact miniature camera module
- medium pixel count (5-20k)

Addressing widest range of use cases with highest accuracy

Front-facing

- 3D imaging/video with best user experience
 - Biometric authentication
 - Face recognition
 - Personalized avatars/emoticons
 - Bokeh effect selfies
- Gesture control
- Eye-contact

World-facing

- AR apps and games
- Background removal
- 3D indoor mapping

Addressing broad range of use cases with good enough accuracy

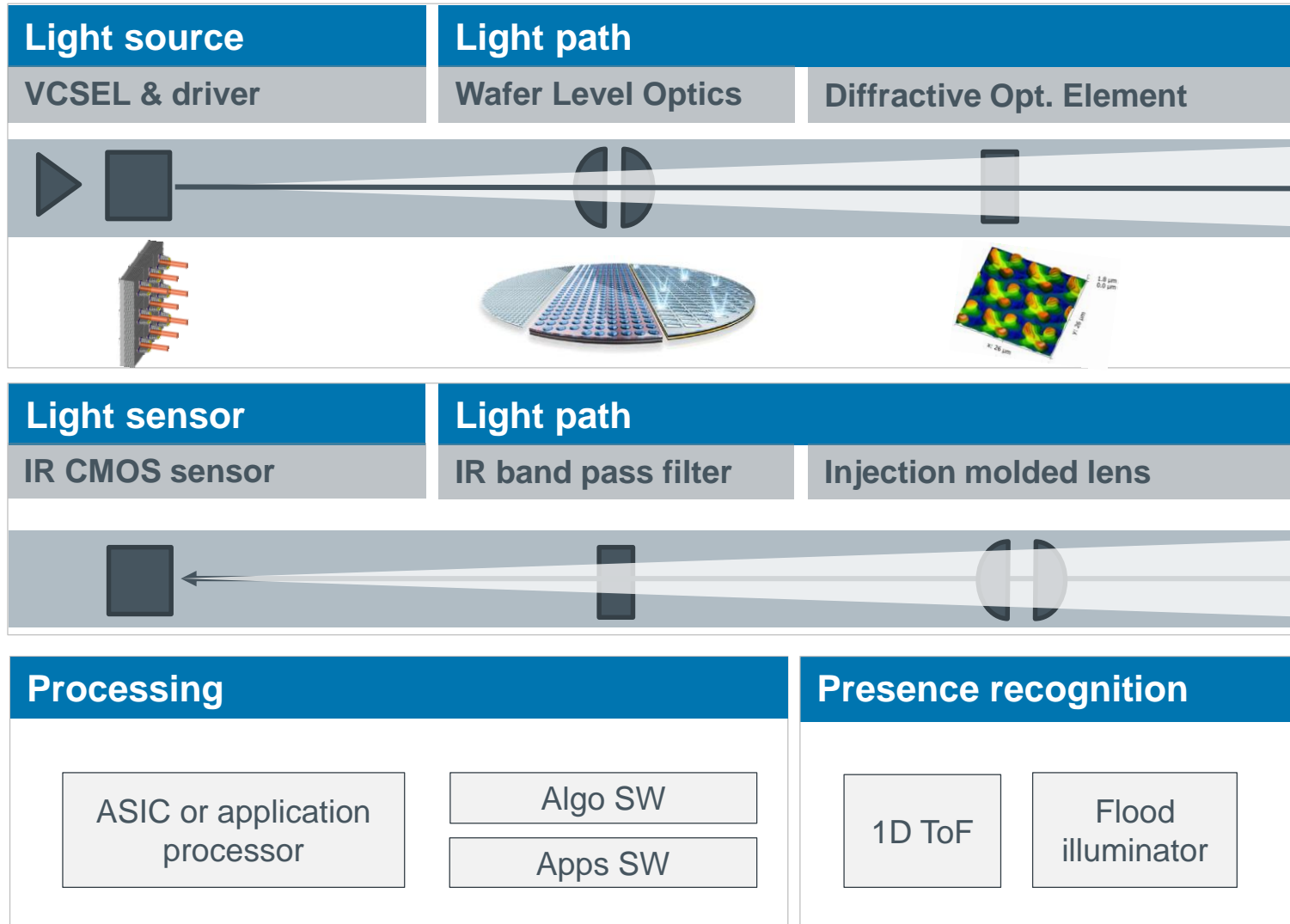
Front-facing

- Basic 3D imaging/video with decent performance
 - Face recognition
 - Morphing/Face shifting
 - Perspective correction and panoramic selfies
- Proximity and presence detection
- Camera autofocus

World-facing

- AR apps and games
- Background removal
- Camera autofocus

Structured Light system architecture



Structured Light: how does ams differentiate

End-to-end system-level integration know-how: from components to algorithms and optimized applications

- Optimizing user experience, BOM, geometry and software integration simultaneously
- Special emphasis on accuracy, temperature stability, eye safety, beam divergence

Illuminator

DOEs:

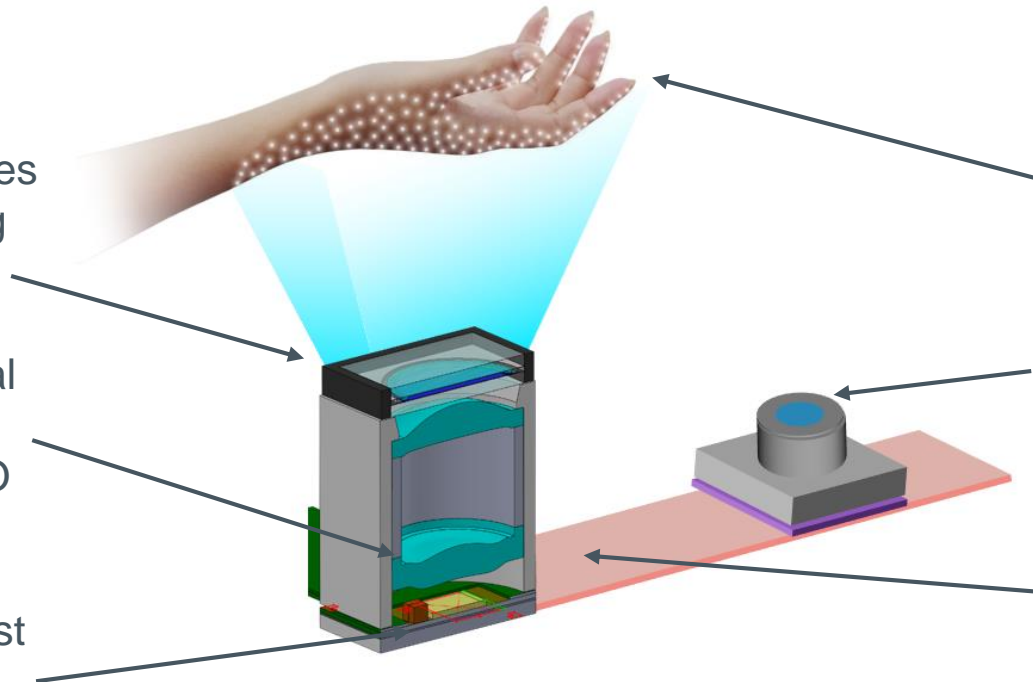
- Strong DOE design capabilities
- Excellent DOE manufacturing know-how

Projection optics:

- Extensive know-how in optical projector design
- 15+ years experience in WLO manufacturing

VCSEL array:

- Best-in-class VCSELs: highest efficiency, smallest pitch



Structured Light system

Dot pattern & Algorithms:

- In-house software development, strong expertise in dot pattern design

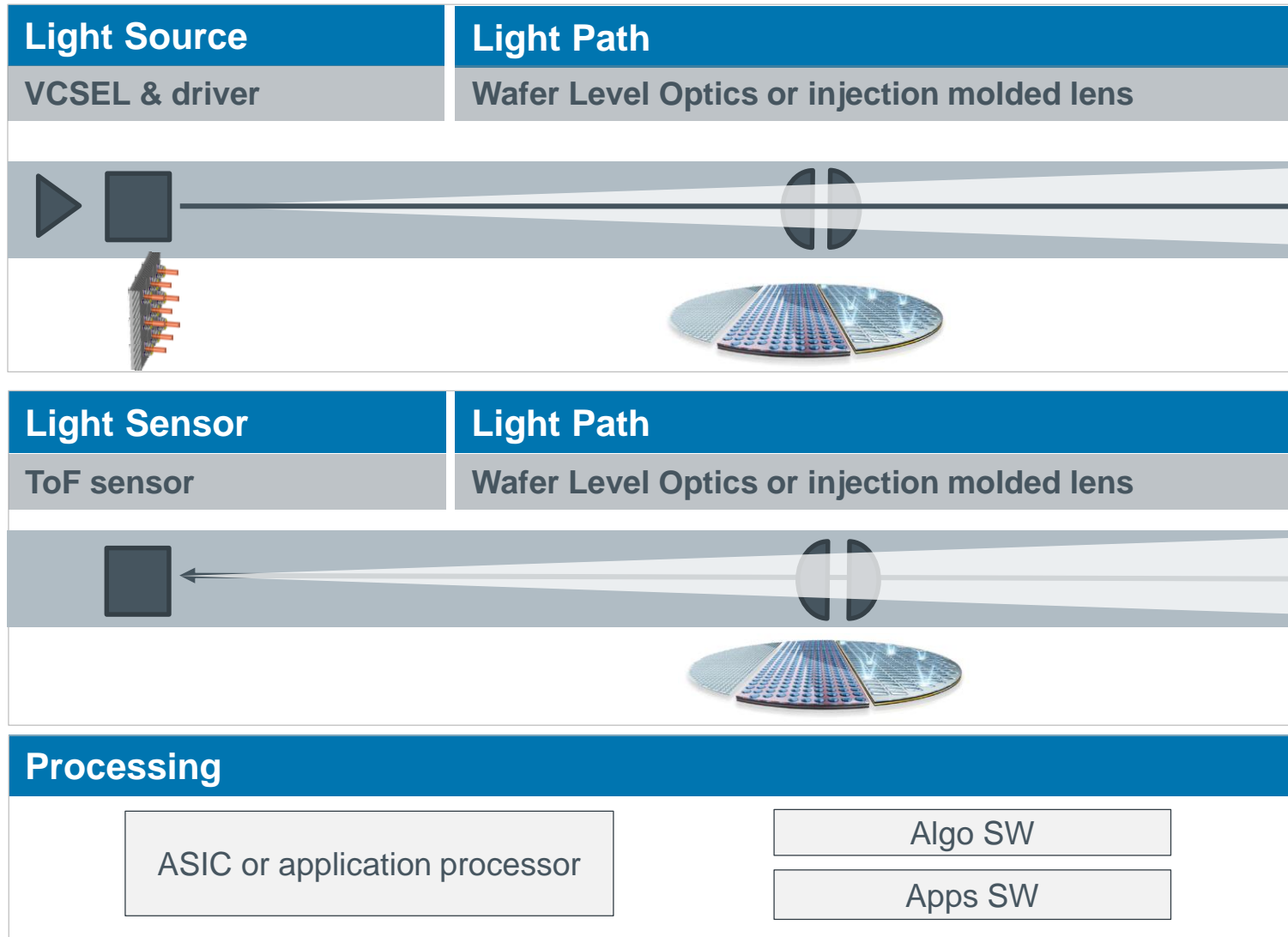
Imaging channel:

- Development of in-house sensors with global shutter pixels

Assembly & integration:

- Collaboration with Sunny Optotech: strong partner for active alignment, assembly, testing and lens molding

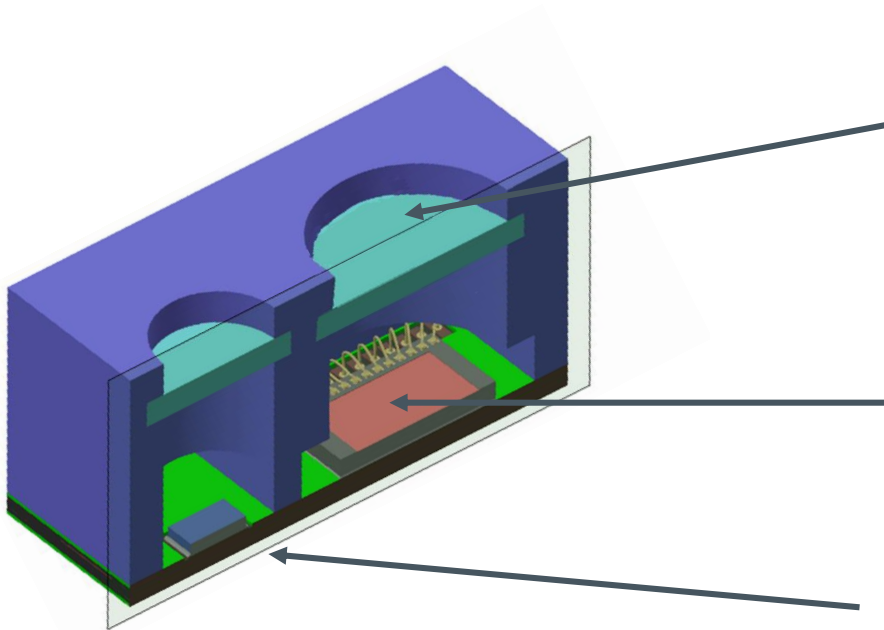
Time-of-Flight system architecture



Time-of-Flight: how does ams differentiate

End-to-end system-level integration know-how: from components to algorithms and optimized applications

- Optimizing user experience, BOM, geometry and software integration simultaneously
- Special emphasis on miniaturization, outdoor performance and speed



Optics and packaging:

- Compact module design based on wafer-level packaging technologies
- Best-in-class optical design capabilities

ToF sensor chip:

- World-leading high performance pixel design with robust ambient light immunity, low power consumption
- Unique know-how on ToF technology and metrology systems

VCSEL illumination:

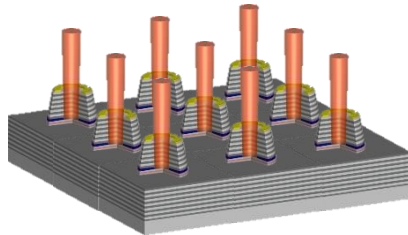
- Best-in-class VCSELs: highest quantum efficiency, very short pulses, exactly tailored emission angles (2-3x narrower than competition)
- Flood illuminators: uniform beam shaping with in-house micro-optics

VCSEL technology is the key building block for 3D

Recent 3D deployments proof that VCSEL is the clear winner over LED and EEL

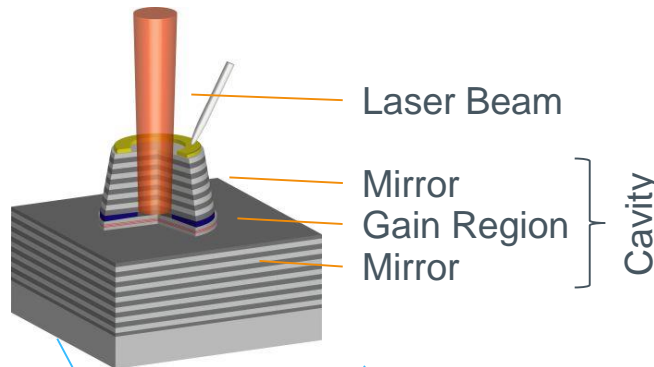
VCSEL Array

Multiple emitters on one die



VCSEL

Vertical Cavity Surface Emitting Laser



Vertical emission

- Compatible with surface mount architecture
- Lower cost, better suited for consumer than edge emitting lasers

Beam quality

- Circular beam, Gaussian profile
- Small divergence
- More efficient light control

Narrow wavelength

- Better background light rejection
- Lower system power consumption

Speed

- High modulation frequency, short pulses
- Better signal-to-noise, lower power

Array configuration

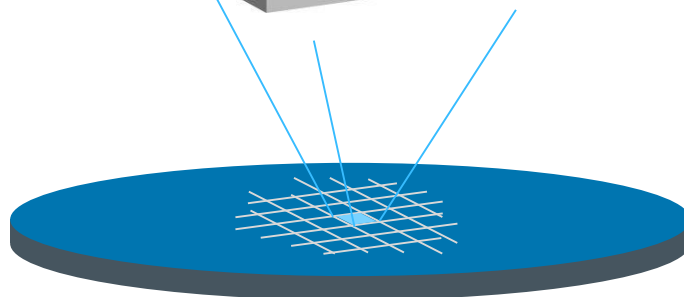
- Higher power at lower cost, less speckles
- Addressable arrays: illuminate ROI, save power
- More flexibility than edge emitting lasers

Cost

- Above factors in combination provide lowest overall cost per solution

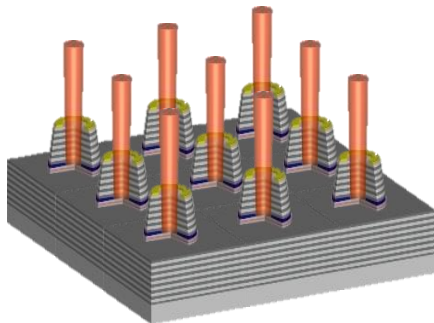
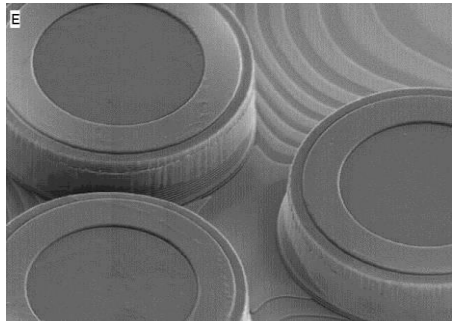
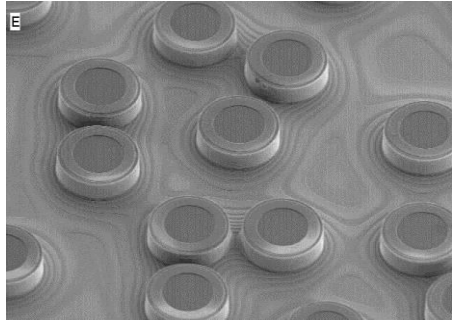
Wafer

Thousands of dies



ams unique VCSELs as key to 3D success

Princeton acquisition enables even stronger mobile and automotive 3D play



Acquisition of Princeton Optronics – superior high power VCSEL technology

- Leading provider of high performance VCSELs with over 15 years of IP development
- Completed full optical value chain coverage

Leading VCSEL and VCSEL array technology for

- Smallest pitch
 - Best efficiency
 - High beam quality
 - High power
- Better resolution and/or lower cost
Record 63% (quantum efficiency, typical 45-50%)
Low beam divergence at high power, high efficiency for DOE systems
From mWatt to a few Watt, even up to 100+ Watt, prerequisite for automotive play

VCSEL manufacturing

- Producing high power VCSEL in high volume since 2000 (external suppliers)
- Investment in new highly differentiated 6" manufacturing line in Singapore with capacity of 2000 wspm
- Further capacity increase under evaluation

Automotive: in-cabin 3D sensing use cases

Full reuse of technology investments into Structured Light & ToF



Driver face recognition / authentication

- Automatic driver settings
- Advanced car sharing
- Biometric authentication



Driver monitoring

- Alertness
- Distraction warning
- Air-bag deployment



Advanced gesture control

- More accurate
- Broader applications

Automotive: future 3D LIDAR systems

The next growth wave in automotive beyond 3D in-cabin sensing



Autonomous driving expected to require multiple solid state 3D LIDAR systems per car

Significant TAM starting to emerge after 2021

Requires very high power VCSEL illumination

Princeton VCSEL technology uniquely positioned to address market requirements

- Addressable high count VCSEL arrays enabling solid state architecture
- Very high power VCSEL arrays (industry leading, 100+ Watt)
- Low beam divergence for long range operations (100m+)

Technology definition ongoing, already started to engage with tier 1 system players and disruptive entrants

Key takeaways

3D sensing leadership



ams enabled major high volume 3D sensing deployments in mobile in 2017

Strategic focus on consumer and automotive, technology leadership and system expertise: platform to capture vast majority of the 3D sensing market

- Massive growth ahead in 3D sensing, predominantly in consumer applications (CAGR 2017-22E: 74%)
- Second growth wave in automotive expected to start around 2022

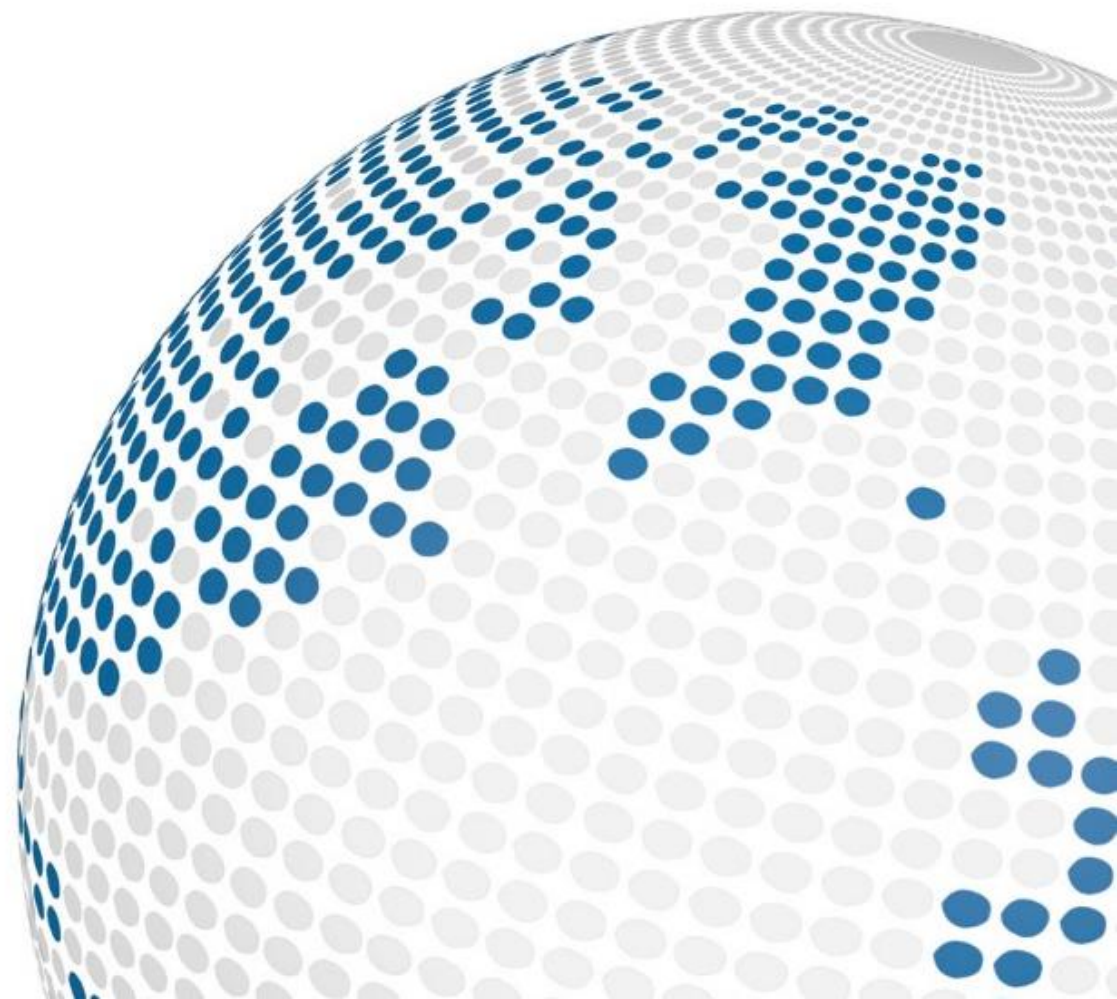
Unique portfolio and strong investments into Structured Light, ToF and VCSEL enable full 3D solution play

- Leading design and manufacturing capabilities
- Manufacturing experience and capacity investments
- Highly differentiated VCSEL and VCSEL array technology

Investments beyond 3D components such as software and co-operations allow tailored engagements with 3D sensing ecosystem players (OEMs, ODMs, Mobile OS, software partners)

Light and spectral sensing

Jennifer Zhao
Executive Vice President & General Manager
Division Advanced Optical Solutions



Optical sensing

Light sensing

- Display intensity management
- Camera/Display color balance
- Proximity (mobile/home assistants)

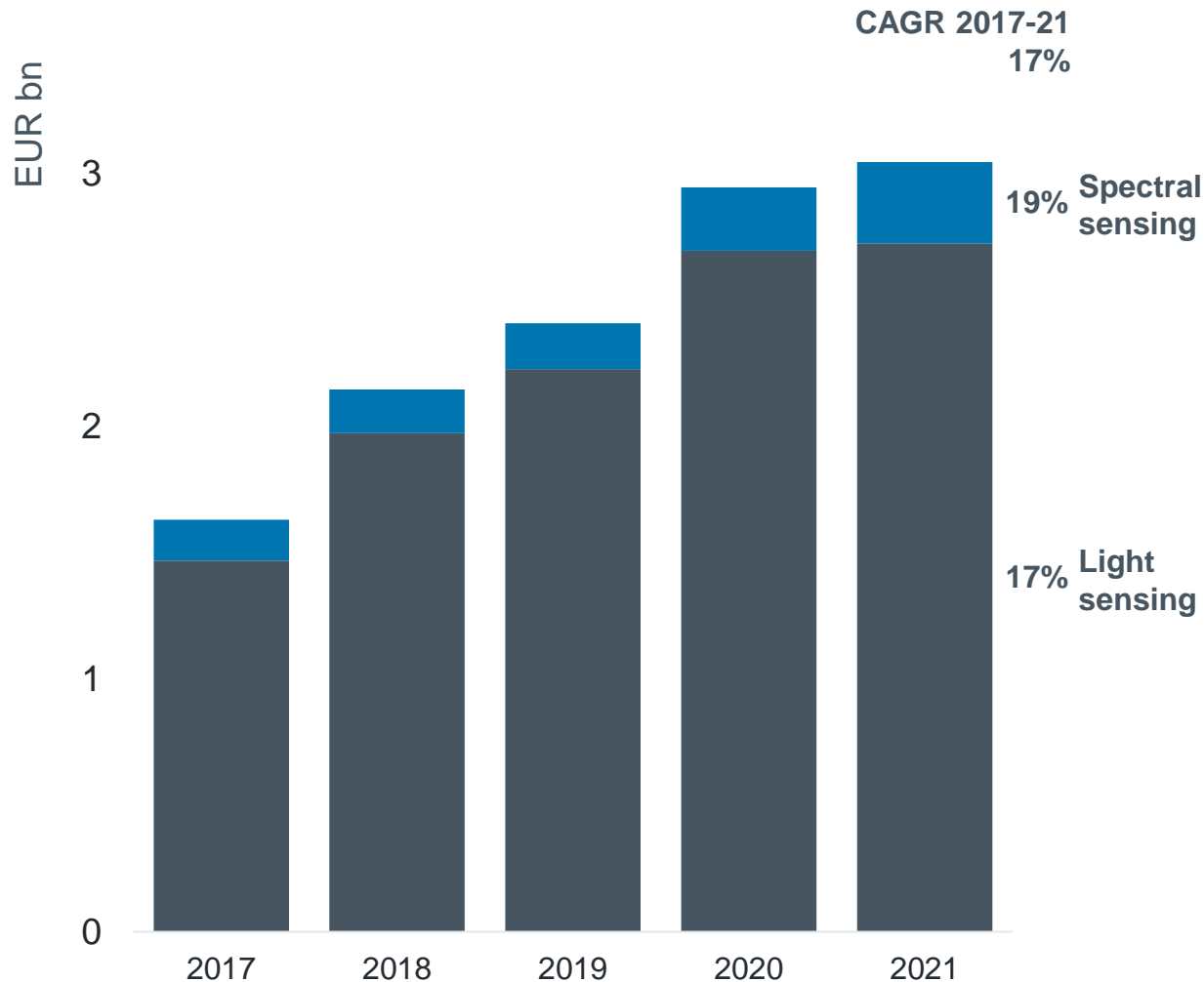


Spectral sensing

- Color matching in e-commerce
- Food analysis (maturity/sweetness)
- Cosmetic and skin tone monitoring



Optical sensing market



New growth areas in spectral sensing driven by innovative applications

- Skin tone matching
- Color matching in e-commerce
- Food analysis

Continuing growth in light sensing with XYZ display management adoption at China mobile OEMs

New solutions and applications in mobile

- Handset industrial design creating new solution requirements
- Light sensing expanding into lower tier markets

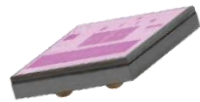
Optical sensing technology

Evolving to greater information content enabling new applications

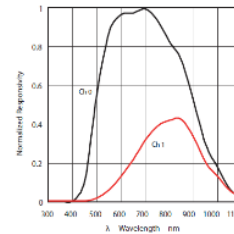
Optical sensing evolution



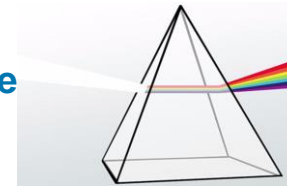
Ambient light sensor



Dual-diode ALS



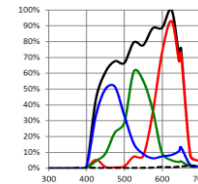
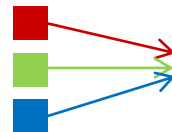
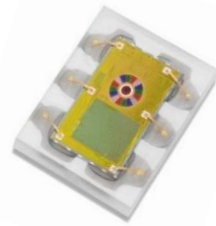
White light



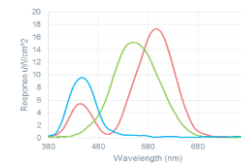
Brightness/illuminance



Color sensor

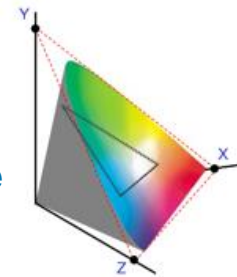


R G B

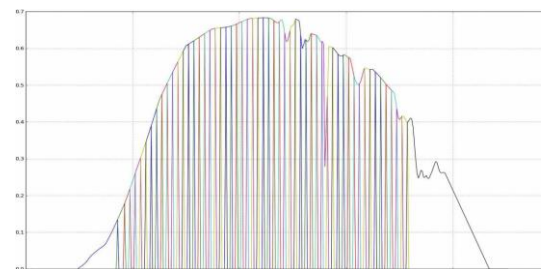


X Y Z

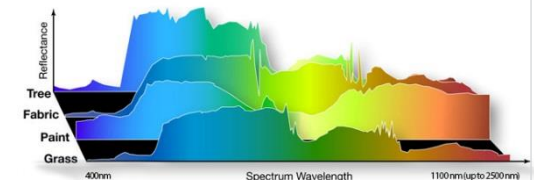
Color space



Spectral sensor



Spectral signature



ams is the market leader in light sensing

Leading position driven by strong product attachment at top 15 mobile OEMs



Ambient light sensing (ALS)

Use of ambient light measurement to adjust display brightness



Proximity sensing

Use of reflected light to detect distance to head and enable key handset functionality



Color sensing

Detection of color components to improve display viewing performance

“Paper-like” display technology

Adjusting display white-point to match the ambient illumination color temperature



The human eye easily detects even very small color variations

Our XYZ sensor is 5x more accurate than an RGB sensor

Enabling displays to look like paper

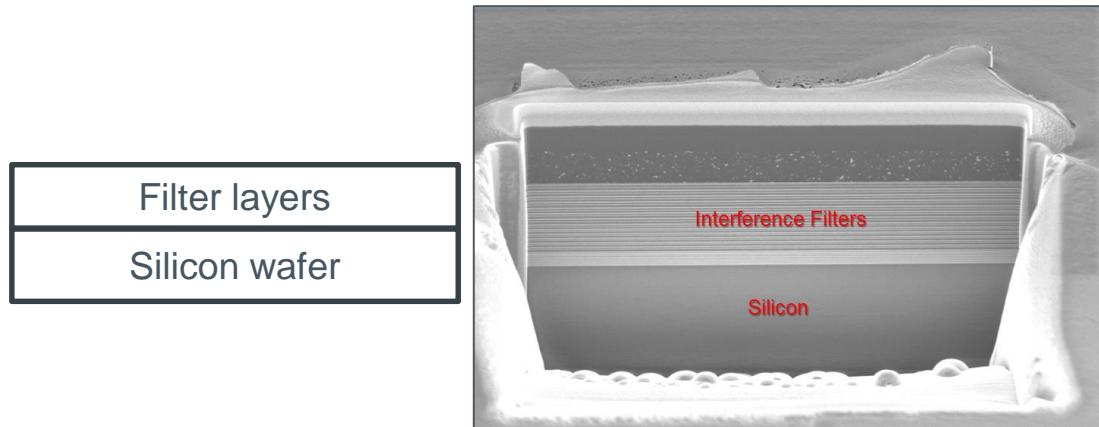
- Better outdoor readability (sunlight)
- Monitor ambient light conditions
- Adjust for print-like readability
- Minimize digital eye strain

Shift white balance display light at night

- Blue light negatively affects “circadian rhythm” causing poor sleep quality
- Shifting displays white-point to warmer color temperature improve sleep cycle

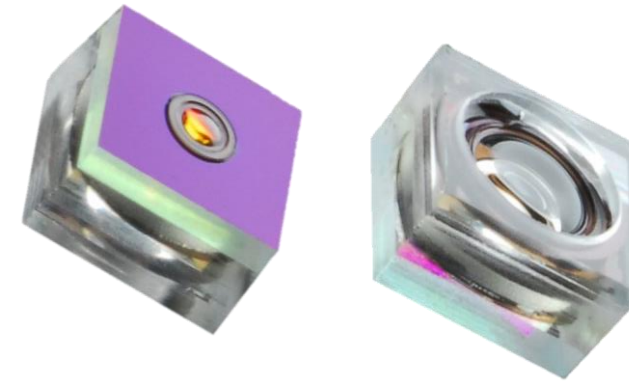
Delivering differentiation

Leveraging intellectual property to create unique products



Color filter technology

- Interferometric filters deposited directly onto wafer
- Completely in-house at Austria and Singapore ams facilities
- No other sensor supplier offers this capability today

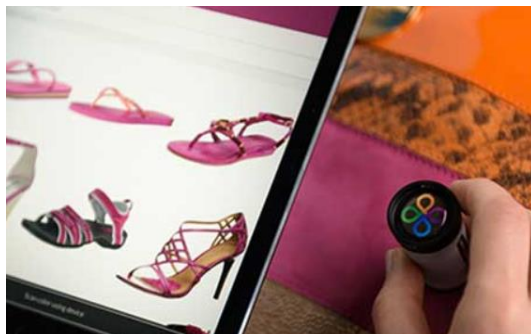


Micro-optical packaging

- Vacuum injection molding
- Wafer level optics and stacking
- Wafer level package integration

Spectral sensing – the next growth driver

Unleashing knowledge and opportunity through spectral sensing



Color matching

Improving online shopping
customer experience



Skin tone and cosmetics

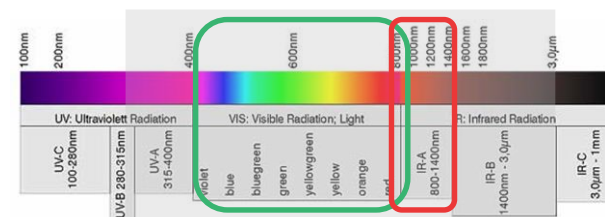
Monitoring skin whitening
and cosmetic color
matching



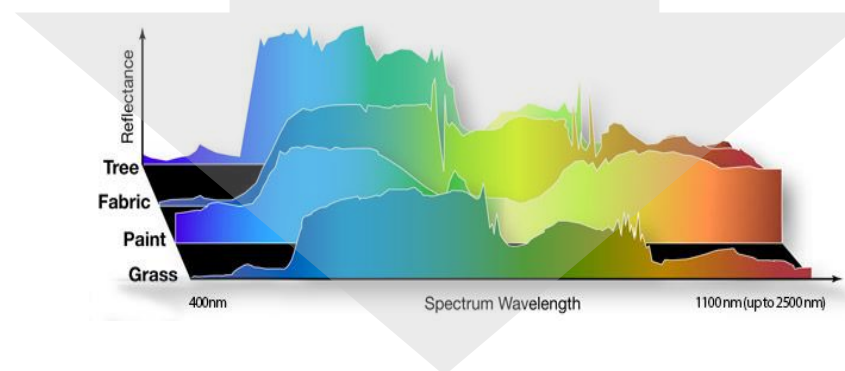
Food analysis

Determining sweetness
and freshness

Measure object visible and/or IR light range



Obtain object spectral signature



Make a decision with
new feature or application

Spectral sensing to boost online shopping sales

Color matching application – improving the online shopping customer experience

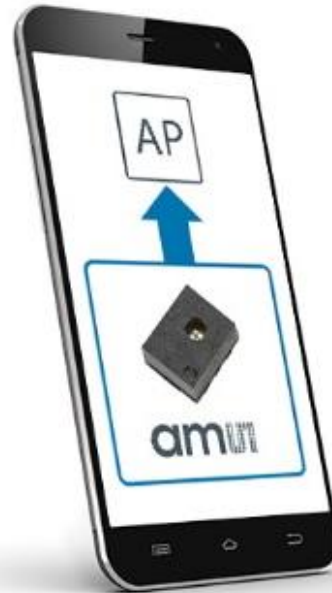
Can color measure
any material

- Printed paper
- Fabric
- Plastic
- Paint
- Wood
- Clothing

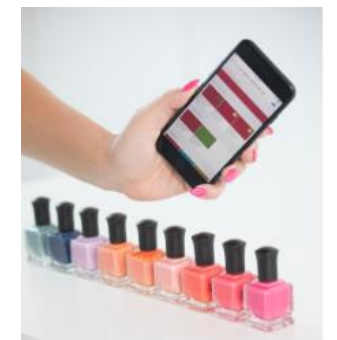


Item to match

Cloud database



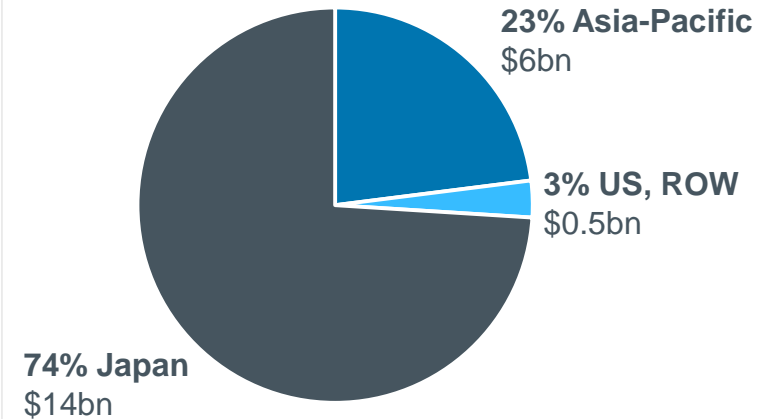
Match!



Cosmetics and skin tone measurement

ams and partner to offer global skin tone measurement solution

2018 Skin whitening market*



Skin whitening

The skin whitening market is a USD 20bn market already in 2018

Cosmetics

Partner delivers cosmetic color measurement, color guidance, and laboratory services to global cosmetic brands and retailers

- Solution measured over 100m consumers in stores
- Partner has the widest skin color standard in the world
- More than 20,000 products in cosmetic database



*Source: ComCap media study, Oct. 12, 2016

Food quality analysis

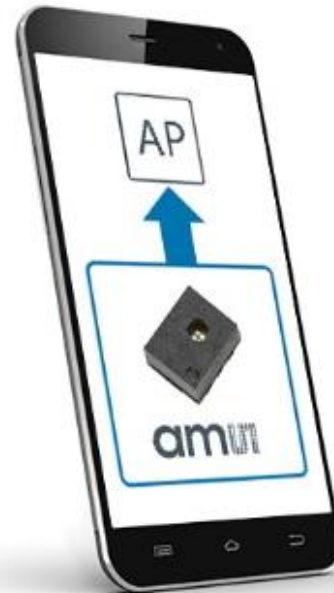
Multi-channel spectral sensors solutions enabling exciting new applications

Selected fruits and
vegetables



food to analyze

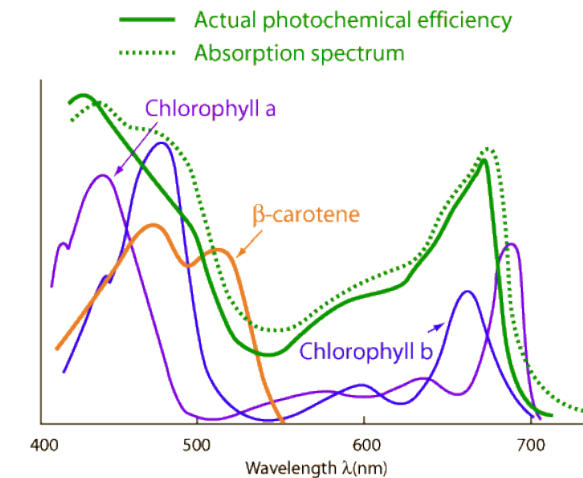
Cloud database



Food quality
analysis

Determine food freshness

- Sweetness - Brix level
- Harvest stage - Chlorophyll level
- Frost burn - Fruit skin smoothness



Targeting future applications like
presence of allergenes

Key takeaways



The global leader in optical sensing

Pioneering optical sensor solutions supporting top 15 smartphone OEMs

Enabling customer differentiation with new features

- “Paper-like” viewing
- Auto white balance for cameras and displays



Spectral Sensing will be a next growth driver enabling new applications

- Color matching for online shopping
- Cosmetic and skin-tone measure/monitoring
- Food quality analysis



Image sensing

Stéphane Curral
Senior Vice President & General Manager
Division Image Sensor Solutions

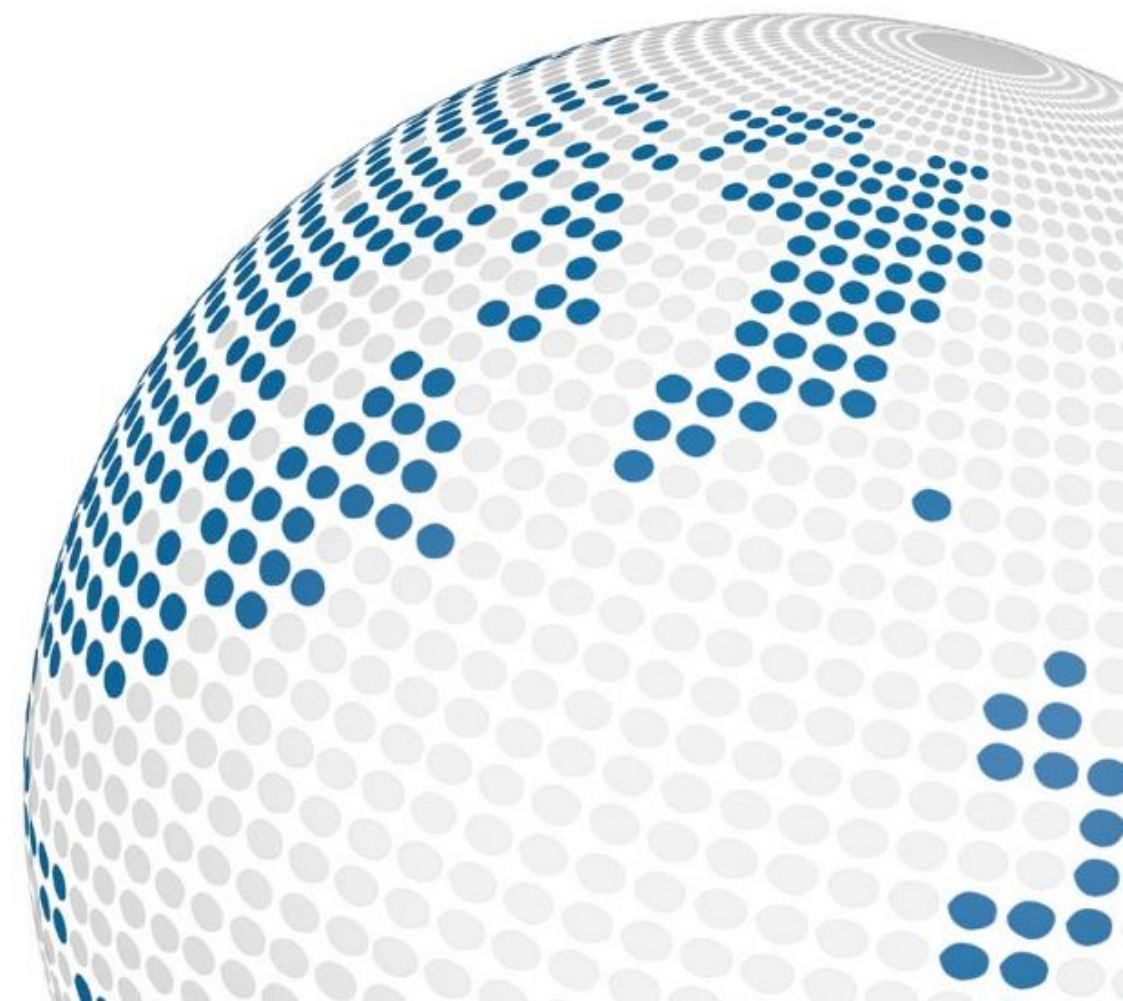


Image sensing

Industrial

- High speed image sensors for machine vision
- Image sensors for high-end photo and 4K/8K video
- Optical sensing convergence, hyper-spectral sensing



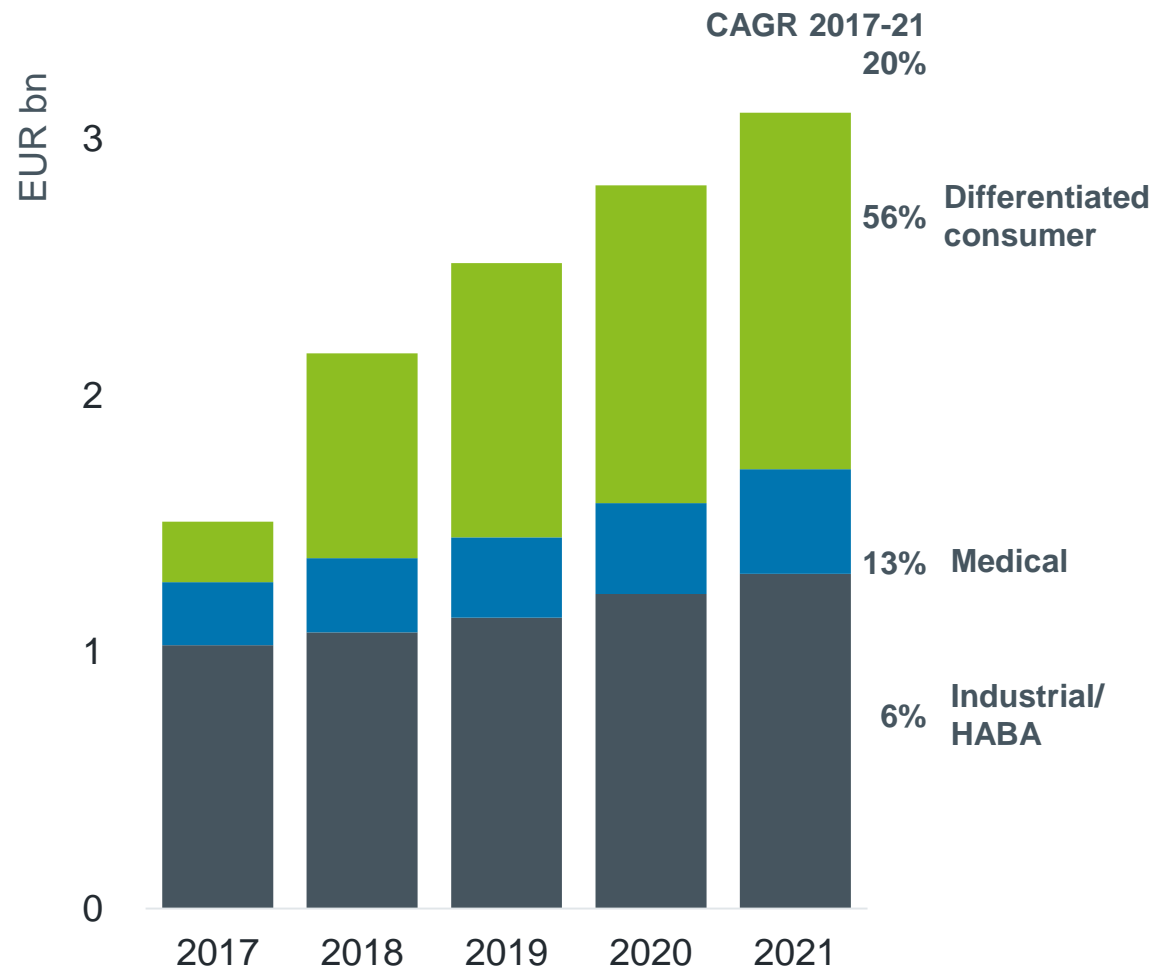
Medical

- High performance Computer Tomography (CT) sensor solutions
- High image quality X-ray flat panel readout ICs
- Low-cost wafer scale X-ray detector
- Micro camera modules for disposable endoscopy



Solid growth in industrial and medical segments

Investing in differentiated high growth consumer markets



Source: ams market model and external reports

Growth in industrial markets accelerated by Factory 4.0

- Increasing demand for high-speed/resolution machine vision systems
- Growth in automation with collaborative robotics
- Acceleration of smart meter adoption
- Increasing need for customized and off-the-shelf sensor interfaces solutions

Growth in healthcare diagnostics driven by growing and ageing worldwide population

- Medical Endoscopy: disposable endoscopy growth requiring cost effective miniaturized solutions
- Medical Imaging: growing demand for clearer images at lowest radiation dose and lower system costs

Opportunities in high growth differentiated consumer applications

- 3D Structured light & eye tracking

Differentiated/leading player in machine vision



Strong share in double digit growth market

- Serving leading accounts in Machine Vision, taking position in China

Covering a wide range of applications

- Machine vision and factory automation
- Barcode readers and document scanning
- Intelligent transport (ITS)
- Motion capture and 3D

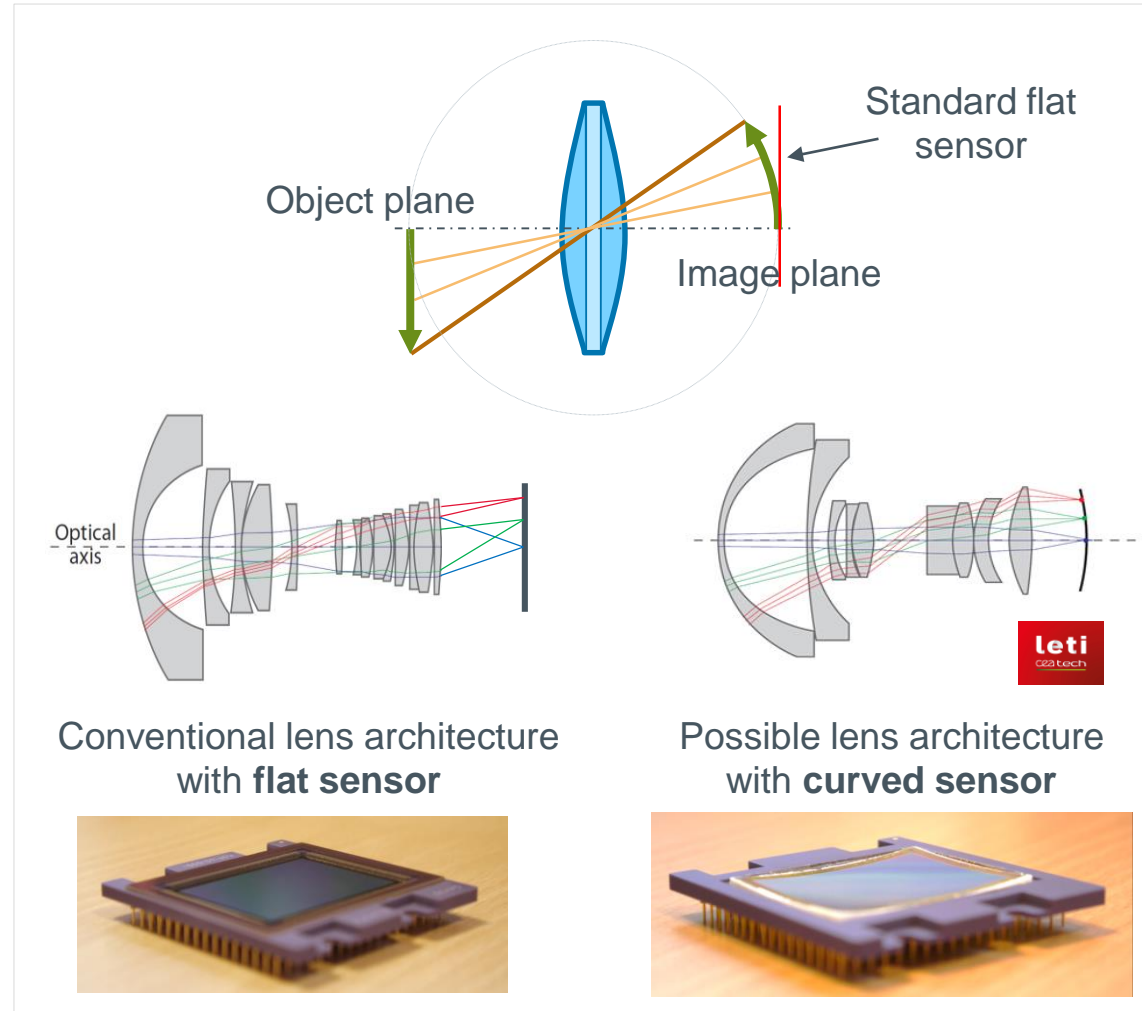
Top image performance at high speed

- Highest dynamic range
- Highest frame rate, up to 70 Gbps (2 to 4x competition)
- Smallest global shutter pixel to market

Technology leverage to near-infrared (NIR) sensors

- Strong IP portfolio in global shutter pixel
- Protected IP for diffractive light trapping technique

Continuing innovation in imaging



Curved image sensors

Opportunity

- Optical aberrations in every optical design
- Complex lenses needed to flatten image into image plane (field curvature aberration)
- Alternative: curved image sensors

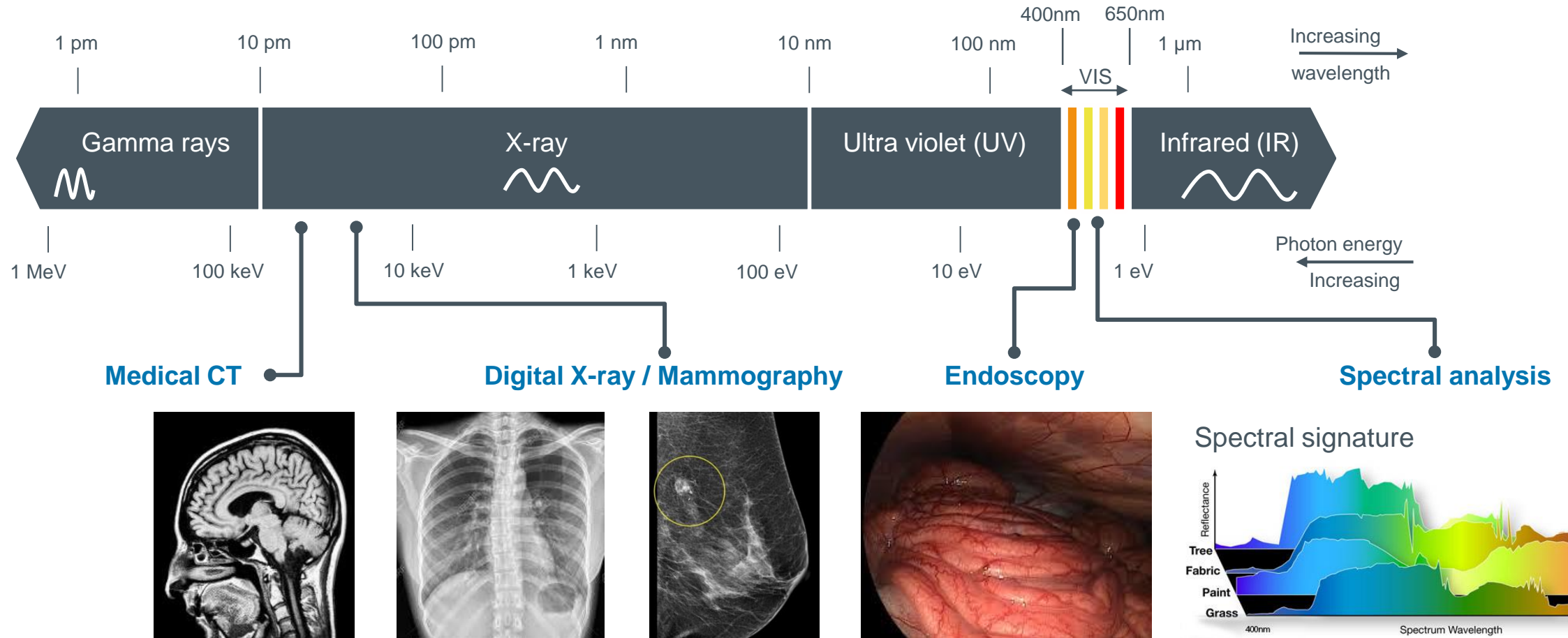
Benefits

- Optical system simplification
- Improved image quality, better field-of-view (FOV)
- System cost (lower number of lenses, no aspheric surfaces)

Applications (examples)

- Production line monitoring
- Photography
- Camera module (smartphone)

Sensing the whole spectrum in medical



Leading edge solutions for medical imaging

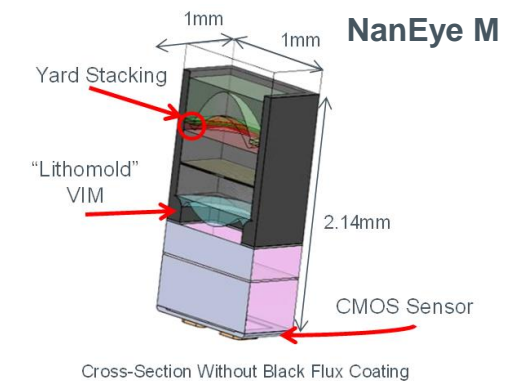
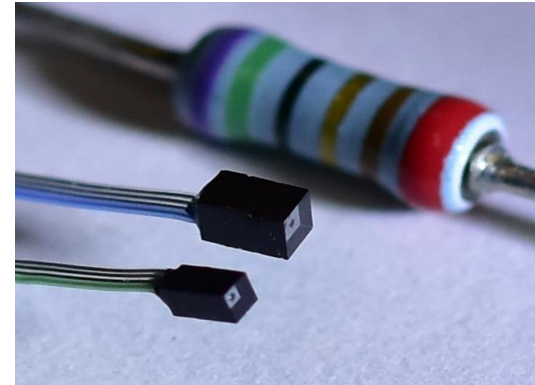
Medical imaging



Clearer images at lower radiation dose

- **3D CT:** Optimized photodiodes stacked on low noise readout amplifiers and high resolution ADCs
- **Low-cost CT:** New concept for 16-slice
- **Low-cost X-ray:** Patented hybrid CMOS technology

Medical endoscopy



Tiniest NanEye ever for disposable endoscopy

- **NanEye XS:** Smaller footprint at similar resolution
- **NanEye M:** Higher resolution, same footprint (1mm²), 3x less distortion, leveraging WLO technology
- Future leverage to other segments/applications

Image and vision sensing technology trends

Imaging becoming ubiquitous, beyond capturing images



Computer vision enables the next gen of visual intelligence tools and mixed realities



Vision as a universal user interface



Always-on vision emitting data about what's happening in a field (event triggers)

Leveraging ams sensing portfolio for unique differentiation

3D sensing	Spectral sensing
✓	✓
✓	
✓	✓

Convergence of imaging and optical: 3D



ams uniquely positioned for broadest range of 3D systems

- From low count pixels (optical) to area sensors (imaging)

3D system optimization capabilities

- Patented approach for synchronization of illumination and image sensor

Differentiated near-infrared (NIR) sensors in development

- Pixel IP, patented concepts for increased NIR sensitivity

Patented hybrid ToF imaging

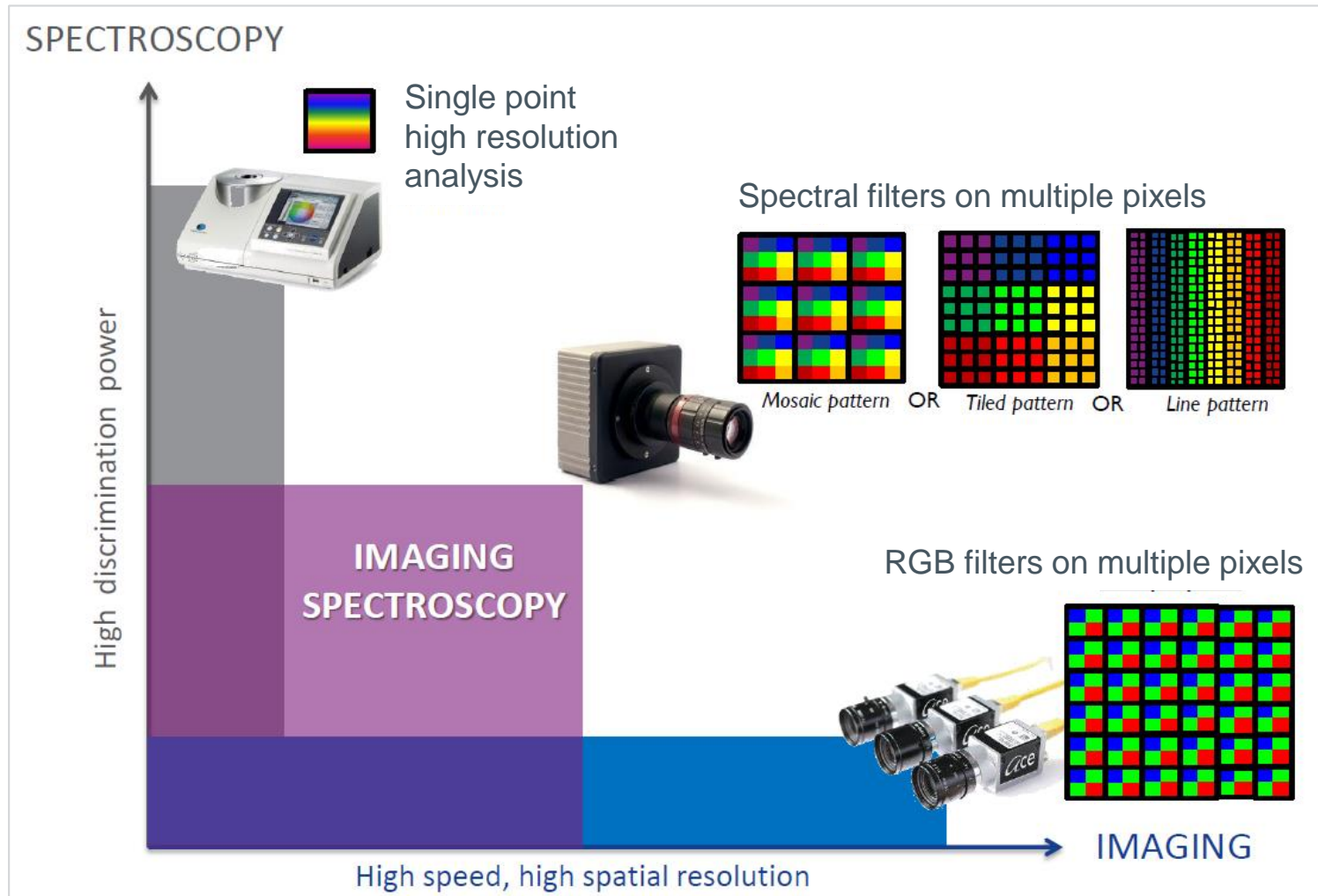
- Image sensor and 3D/ToF (dual mode/convergence)

Technology leverage across markets

- Leveraging 3D/ToF from Consumer to Industrial or Medical



Convergence of imaging and optical: hyper-spectral



Examples of use cases

- Agriculture: Crop analysis
- Retail: Food freshness
- Industrial: Glass inspection
- Printing: True vs. CMY black
- Medical: Tissue analysis
- Consumer: Food analysis

Key takeaways

The next frontier for image sensor solutions



True leader in specific industrial applications and medical imaging

- High speed, high resolution machine vision cameras
- Clearer images at lower radiation dose in 3D-CT and X-ray
- Highest level of opto-electrical performance for micro-camera modules

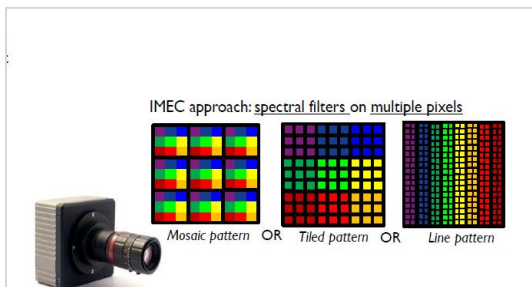
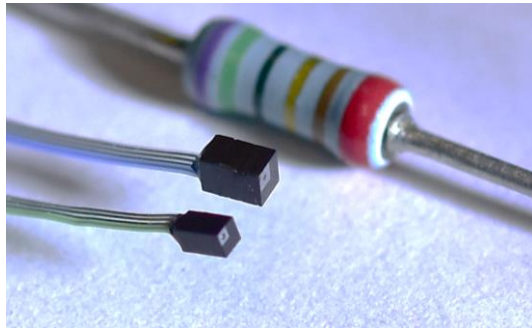
Market growing at 20% CAGR, incl. differentiated consumer applications

Pushing new technology frontiers

- High performance, low cost systems for computer tomography and X-ray
- New generation low cost NanEye, high optical performance, ultra-small footprint
- Curved sensors for improved image quality and optical system simplification

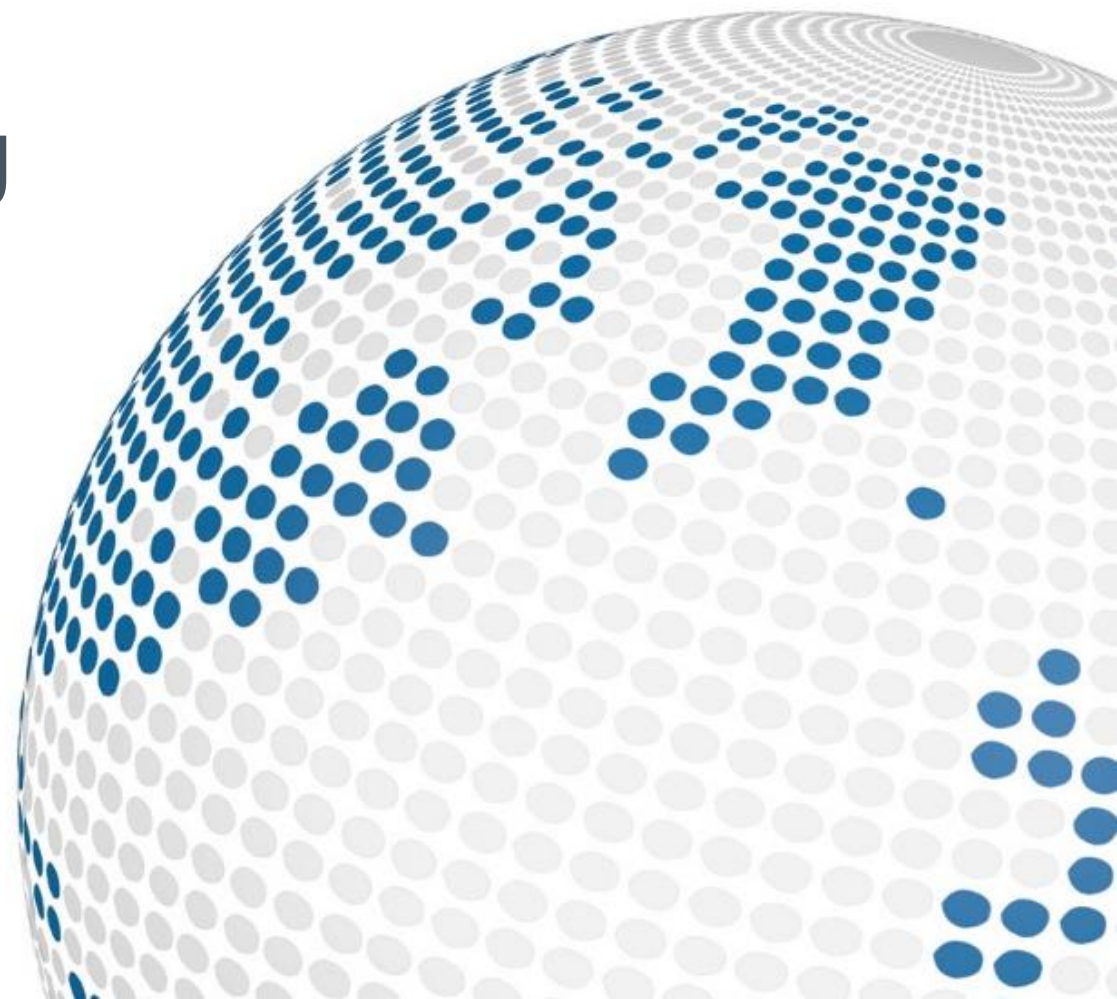
ams uniquely positioned to capture the optical-imaging convergence

- 3D sensing and NIR sensing
- Hyper-spectral imaging (HSI)



Environmental & audio sensing

Mark Hamersma
Executive Vice President
M&A, Strategy & General Manager
Division Environmental & Audio Sensors



Environmental and audio sensing

Environmental sensing

- Complete portfolio for low-power, high-volume, small form factor
 - MOX and infrared gas/presence detection
 - Relative humidity, pressure, temperature
- Multi-sensor modules and monolithic CMOS multi-sensor integration
- Wireless sensor integration

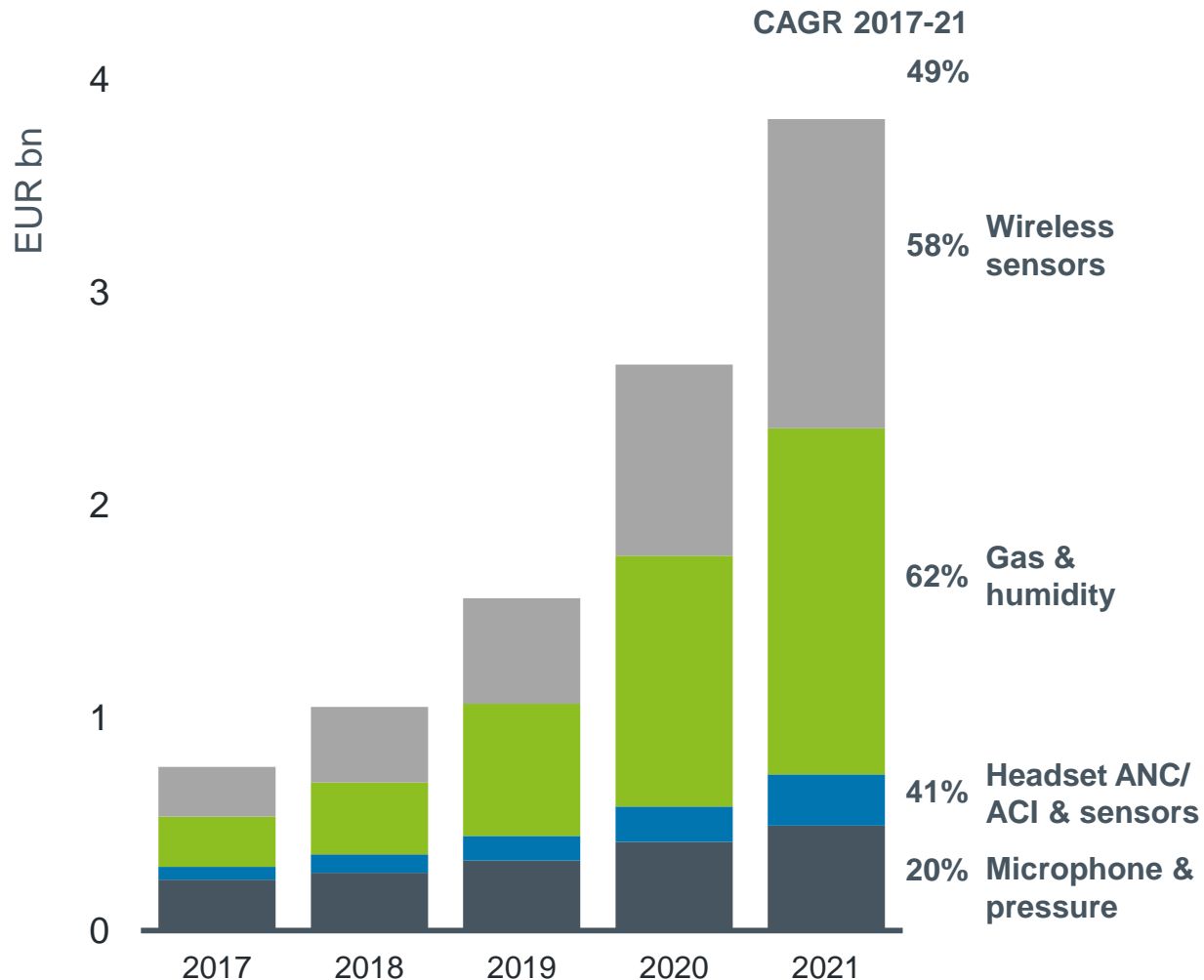


Audio sensing

- MEMS microphone ASICs
- Best-in-class active noise cancellation (ANC) ICs
- Smart accessory interface solutions



Accelerating growth in environmental and audio



Compelling growth in gas and humidity sensors

- Short term in smart home control & appliances, followed by mobile in 2019/20
- Multi-gas (MOX/IR) and particle measurement modules for full environmental monitoring solutions

Double-digit growth in microphone + pressure

- Increasing number of MICs per phone/tablet
- Large new voice control market for MICs
- Temperature and pressure integration with MICs driving significant ASP growth

High-growth Audio ANC and ACI market

- ANC adoption in mass market headsets
- Accessory communication interface (ACI) adoption for high-speed accessory communication and charging

IoT will drive market for wireless sensors

Uniquely positioned for multi-sensor solutions

Environmental, audio and wireless integration



Environmental					Audio	Ultra-low power wireless
Gas IR/PZT	Gas MOX	Humidity	Pressure	Temp	Sound	
<ul style="list-style-type: none">• CMOS IR sensors• PZT sensors	<ul style="list-style-type: none">• CMOS MOX Sensors	<ul style="list-style-type: none">• CMOS humidity sensor	<ul style="list-style-type: none">• CMOS pressure sensor	<ul style="list-style-type: none">• CMOS temperature sensor	<ul style="list-style-type: none">• Microphone ASICs	BLE
						NFC
						RFID

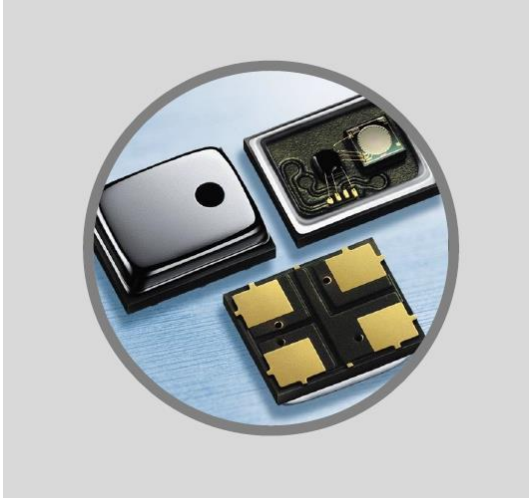
Module and monolithic integration roadmap



Offering for mobile, IoT/HABA and AIM



Market leader in MEMS microphone ASICs



Supplying MIC ASICs to the market leader in MEMS microphones for more than 10 years

Best-in-class analog performance, low-noise and low cost through process technology optimization

Enable and promote integration of other sensors

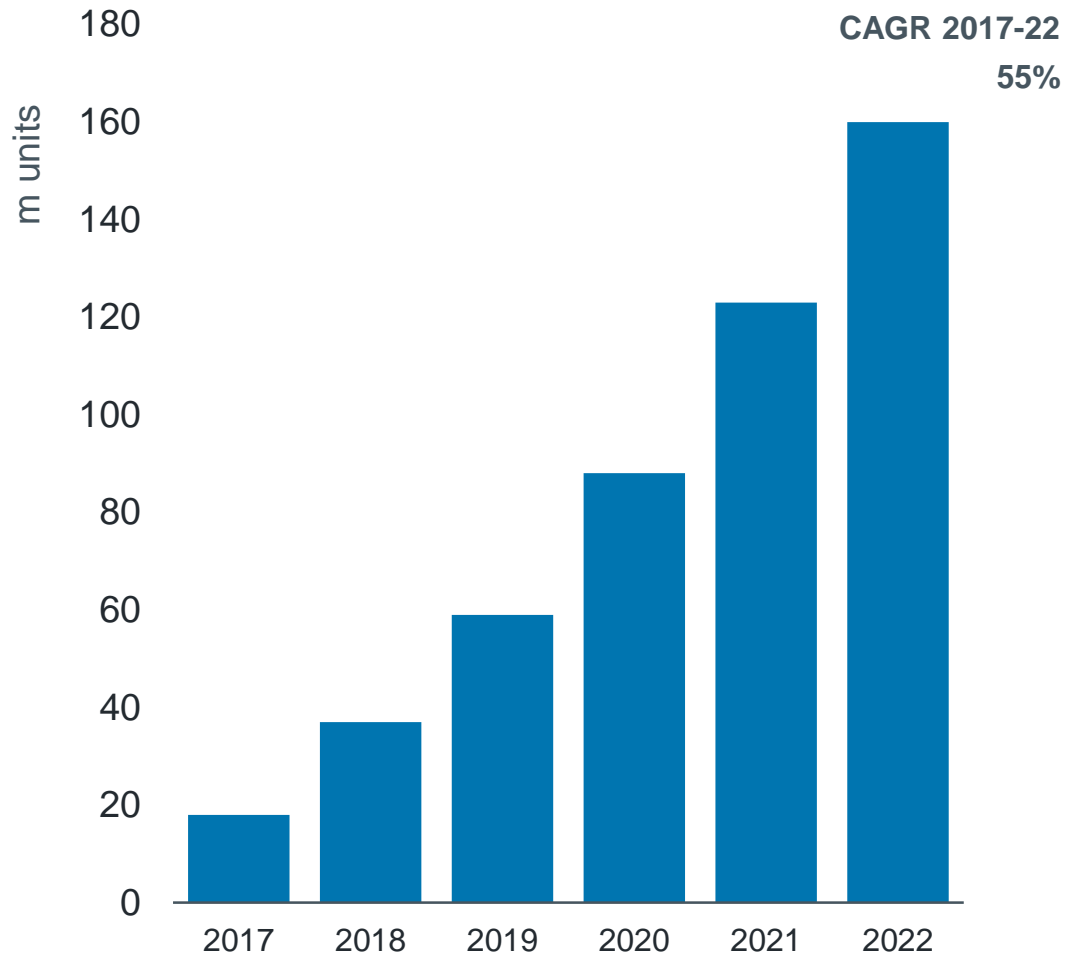
- MIC + temperature sensor already shipping in high volume
- Module integration of pressure in development

Roadmap for monolithic integration of pressure sensor with the MIC + temperature ASIC



Voice control as new MIC growth driver

Intelligent home assistant market



Source: Strategy Analytics

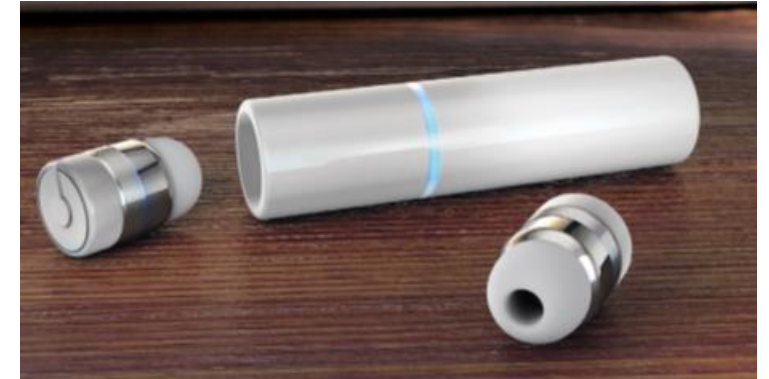
4-8 microphones to support voice control, conferencing and beam forming as well as security/convenience features based on sound classification

Home assistant also perfect hub for environmental monitoring and management

- 4-8 ToF sensors for presence detection
- Environmental sensors for air quality control and alarms
- Spectral sensors for managing room lighting based on light intensity and uniformity readings
- Low-light image sensors for home security



Audio solutions beyond MEMS microphone ICs



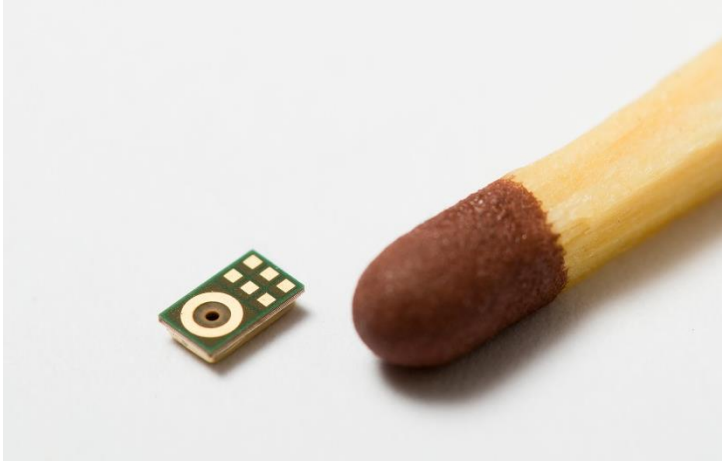
Market leadership in analog ANC

- Best-in-class ANC performance
- Smallest PCB area
- Number 1 in accessory market

Smart accessory communication and power interface (ACI)

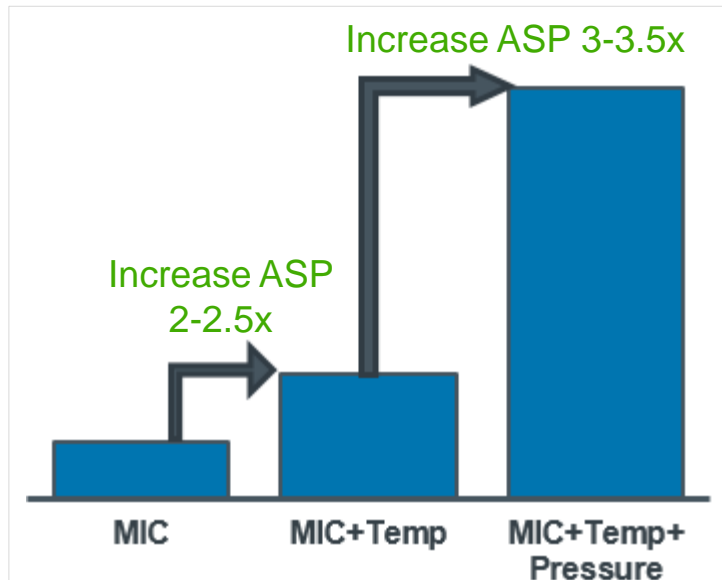
- Enabling ANC and sensor applications on analog headsets without battery in dongle or earbuds
- 2-pin accessory charging including high-speed communication interface

Temperature and pressure integration with MICs



Value increase driven by integration

- MIC + temperature integration in 2017
- Pressure sensors achieving high penetration in mobile phones
- Mobile OEMs reducing number of holes in phone and waterproofing remaining ones
- Pressure integration with MIC for size, cost and power reduction



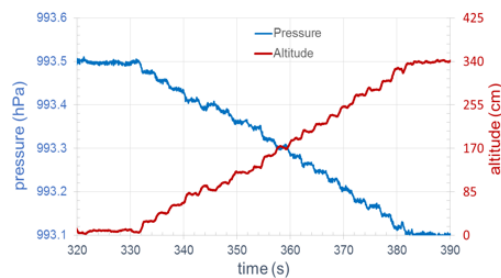
Innovation: monolithic pressure sensor

Opens up new applications

In-door navigation

Staircase

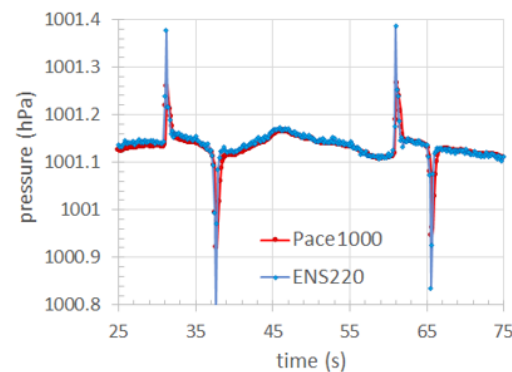
20x 17cm Step height to total a 340 cm rise



Open/close door

Door slam

(0.5 s 20 Pa pressure pulse)



Heart rate monitoring



Drones/AR/gaming



Key differentiators in monolithic capacitive pressure sensing

Excellent sensitivity

- Up to 1cm height resolution (rms)
- 2-5x better than competition




Very fast pressure measurement conversion

- Single shot: 4 milliseconds
- 10-42x better than competition

Ultra-low power consumption

- Pulsed mode: $<2 \mu\text{W}$ @ 1Hz
- 6-23x better than competition

Broad range of gas and particle use cases

	Mobile	HABA	Automotive
 Comfort	<ul style="list-style-type: none"> Indoor/outdoor air quality 	<ul style="list-style-type: none"> Indoor/outdoor air quality Energy saving Presence/occupancy Kitchen ventilation 	<ul style="list-style-type: none"> Outdoor air quality In-cabin air quality (unpleasant gases)
 Health & wellbeing	<ul style="list-style-type: none"> Breath analysis (bad breath/fat burn/condition monitoring) 	<ul style="list-style-type: none"> Presence/occupancy Food spoilage Kitchen ventilation 	<ul style="list-style-type: none"> In-cabin air quality (harmful gases) Tiredness (CO₂ level)
 Safety	<ul style="list-style-type: none"> Toxic gas alarms Long-term exposure – dangerous VOCs 	<ul style="list-style-type: none"> Toxic gas alarms Fire detection Long term exposure – dangerous VOCs 	<ul style="list-style-type: none"> Toxic gas alarms Long term exposure – dangerous VOCs



MOX solution



MOX + PM or IR solution

Need for indoor air quality monitoring

Critical for healthy life and personal safety



We spend more than 80% of our time indoors: home, work, school etc.

Poor indoor air quality can cause fatigue, headaches, irritation, impacting concentration and can cause long term diseases

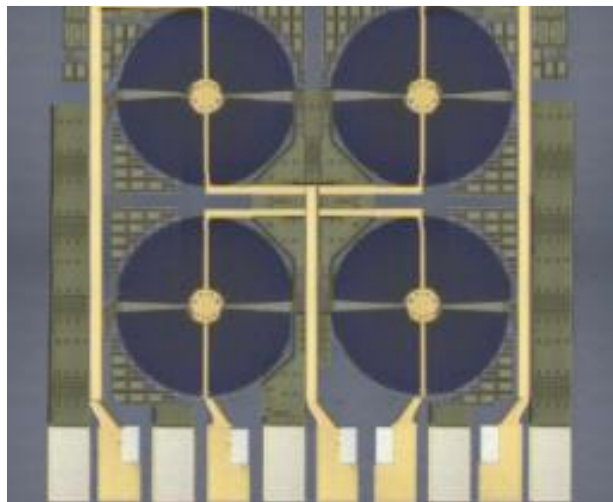
CO₂ is used to control indoor ventilation given that CO₂ levels below 1000ppm indicate good ventilation of the environment but no comprehensive indication on pollution

Volatile Organic Compounds (VOCs) are emitted from different materials (concentration is up to 10x higher indoors than outdoors) and represent a good measurement of indoor air pollution

Allergy and asthma affect more than 20% of the population



Technology leader in gas sensing



Unique track record in gas technology

- 10 years+ of experience in high volume automotive sensors
- Combined patent portfolio of 3 pioneers: Applied Sensors, NXP, CCMOSS

Monolithic integration of humidity, temperature, pressure and gas sensors in standard CMOS process

- Ultra-small form-factors, CSP packaging
- Ultra-low power consumption
- Better performance and higher robustness
- More cost effective solution

Multi-gas and particle sensing roadmap covering all key technologies

- Monolithic 4 separate pixel MOX gas and humidity sensor chip
- MOX + IR + particle measurement module solutions roadmap and partnership

Full application solutions including algorithms and selected application software

Enabling wireless sensor solutions

Connecting ams sensors wirelessly to the IoT



Optical
Sensors



Imaging
Sensors



Environmental
Sensors



Audio
Sensors



RFID



NFC



Bluetooth
SMART

Simblee™

Best-in-class standard
wireless solutions

Pre-certified BLE module solutions for
fast time-to-market

Simblee plug & play solution for
interfacing the IoT

Key takeaways

High-growth opportunity in environmental and audio sensors



Market expected to grow at 49% annually over the next four years

- Double-digit growth in MEMS microphone ASICs where ams is market leader
- Compelling 62% CAGR in gas and humidity sensors
- IoT will drive the market for wireless sensors

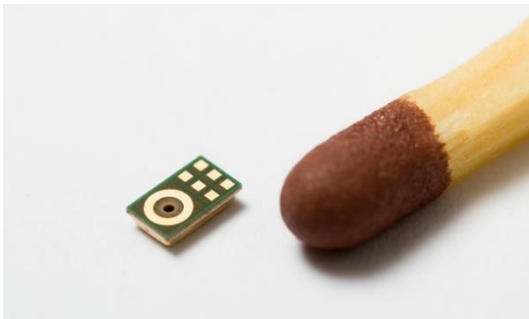
ams uniquely positioned for environmental and audio multi-sensor solutions

- Full portfolio of relevant sensors, sensor technologies and ULP wireless standards
- Mostly CMOS-based technologies allowing monolithic integration
- Full application solutions including turn-key modules and application software



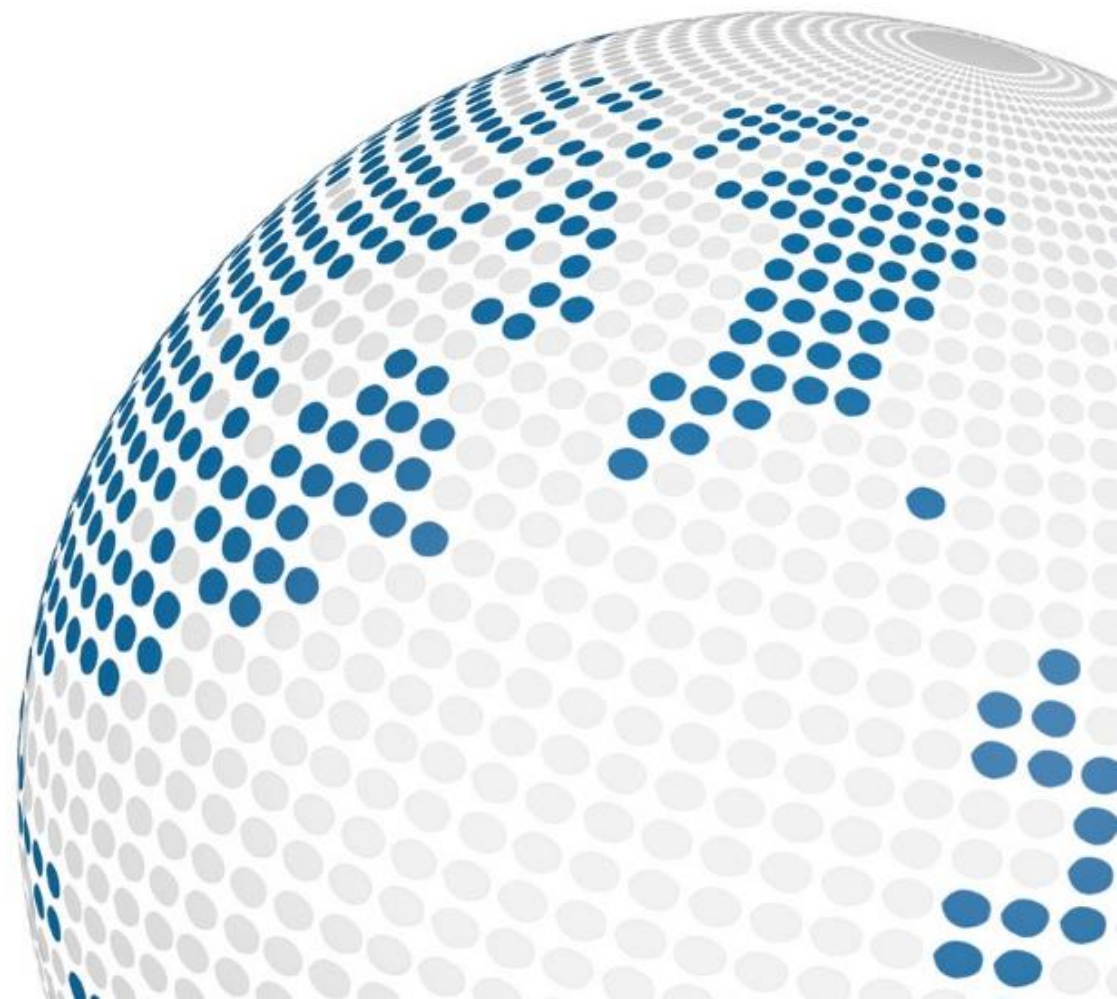
Positioned to clearly outgrow the market

- Major ASP expansion in MICs with temperature and pressure integration
- Highly differentiated new standalone pressure sensor opens up new application markets
- Multi-sensor technology gas and particle sensor roadmap for early, fast-growing HABA, industrial and infrastructure markets



Next frontier sensing applications

Thomas Stockmeier
Chief Operating Officer



Next frontier sensing applications

Next generation sensing solutions driving the digital transformation



E-Nose

Particle sensing

Healthcare monitoring

Spectrometer

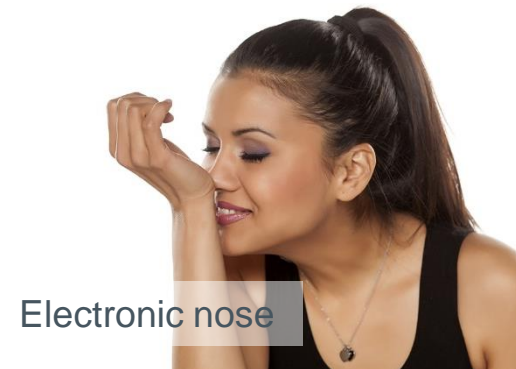
Advanced environmental sensing

Multi gas sensors, electronic nose, particle sensing

High performance gas sensors



Next frontier applications



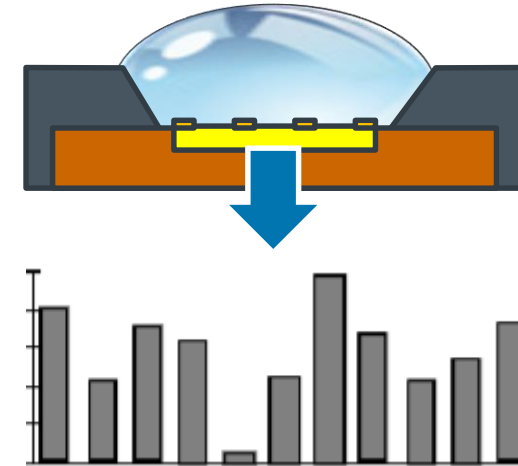
Array of bio diagnostic SPAD detectors delivering a particular smell, taste or disease diagnosis



Miniaturized PM2.5 sensing solutions

E-nose

Miniaturized e-nose for consumer applications



E-nose sensing trends

- Smell and taste are next frontier applications for sensing
- Miniaturized e-nose will enable
 - Point of care diagnostics
 - Identify and search for smells
 - Quality analysis
- Personalized online shopping

ams vision and solutions

- Technologies:
 - SPAD detectors, bio coating
 - Packaging for microfluidics
- Method:
 - Recognition and quantization of proteins
 - Detection of markers: color absorption, fluorescence, and others

E-nose

Personal health monitoring, personalized online shopping and quality analysis

Applications



- Point of care diagnostics



- Online shopping – find what smells well



- Find taste you like



- Quality analysis

Cloud database/service

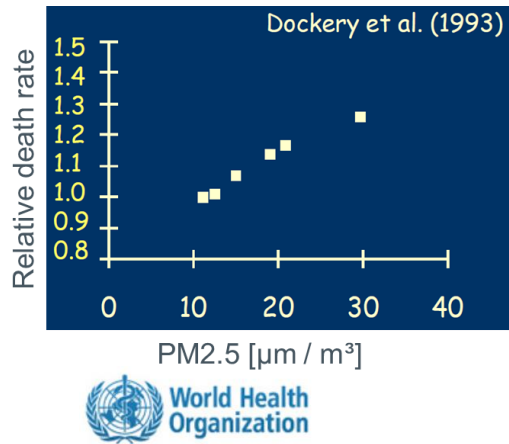


- Painless and harmless hormone analysis – any time
- Identify a smell
- Skin type depended smells search
- Buy similar smells
- Personalized database
- Find wines with similar flavors
- Does it smell fresh?
- Essential amino acids, e.g. leucine, isoleucine

Particle sensing matters for your health

Particulate matter sensor

Applications



- Air quality monitoring for environmental awareness



- Plan a “green” route
- Protect your lungs

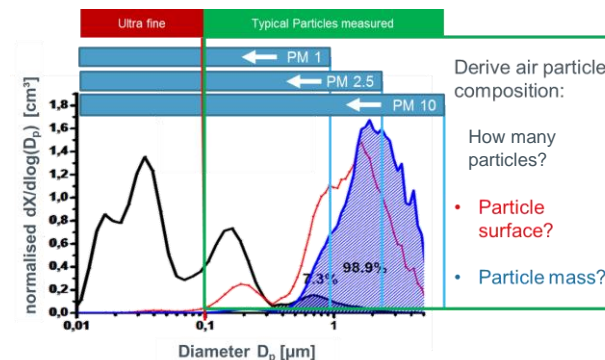


- In cabin air quality
- Air purifier control

ams particulate matter sensing

Innovative miniaturized cost efficient air quality sensors

- PM2.5 sensor
- PM1.0 sensor



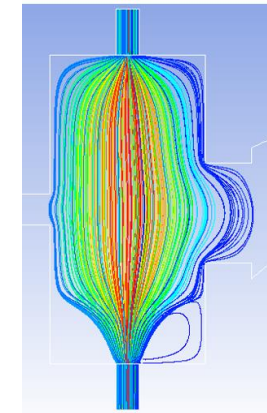
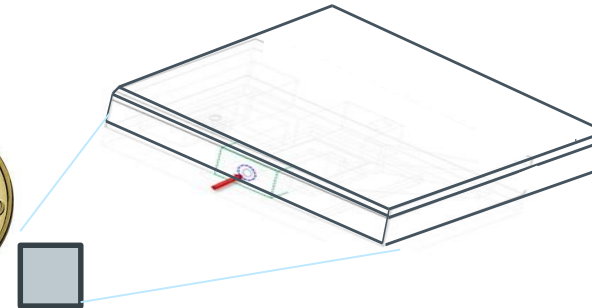
Increased health-related quality of life

Particle sensing (PM2.5)

Miniaturized particle sensor



Shrink
by 100x



Gas flow

Environmental sensor trends

- Measure personal exposure to fine dust
- Minimize exposure (cabin air quality, air purifier, ventilation)
- Combine with other gas sensors to report air quality index
- Predict exposure based on dense network of low cost environmental sensors

ams vision & solutions

- Low cost module for mobile applications
- High quality measurement comparable to expensive lab equipment
- Sensor based on ams IP in the fields of photo sensors, VCSEL and optical packaging
- System size: 8x8x2mm³ (100x shrink compared to existing solutions)

Healthcare monitoring

Evolution from fitness tracking to 24/7 connected health monitoring

Healthcare trends



- Healthcare costs are steadily rising, e.g. 30% of worldwide population is overweight
- Companies bearing the cost will drive adoption (e.g. insurance companies)
- 24/7 remote health monitoring for permanent body tracking is the next step
- Connected devices will measure heart rate, blood pressure, stress level, arterial elasticity, physical resilience to blood pressure or cholesterol levels
- Measurement will be embedded into a wide variety of form factors
- The doctor will call you when something is wrong

ams solutions



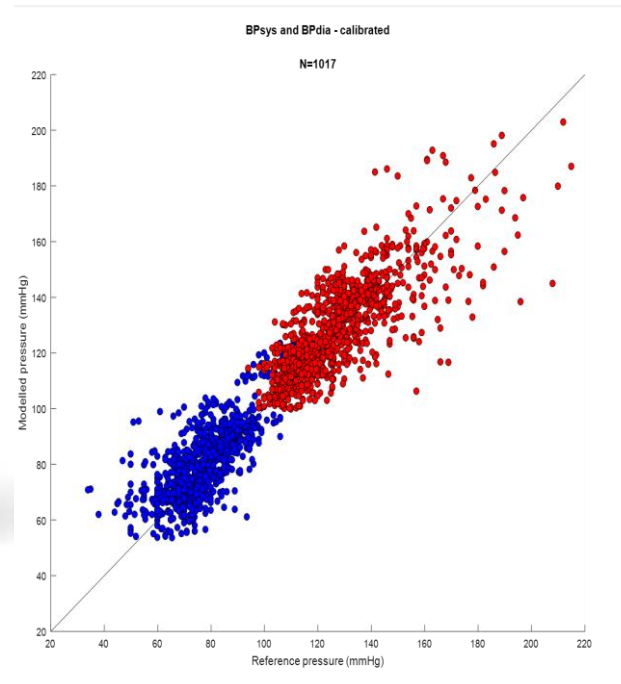
Sensor
algorithms

Sensor fusion
algorithms

ams biosensing solutions
enable 24/7 connected
health devices

Biosensing for health monitoring

Biosensing solutions for heart rate, stress level, blood pressure, arterial elasticity



Health monitoring



- Advanced biosensing for heart rate, blood pressure, stress level, arterial elasticity, physical resilience to blood pressure or cholesterol levels
- Combining multiple sensing technologies: PPG*, ECG**, spectral

Wide range of applications



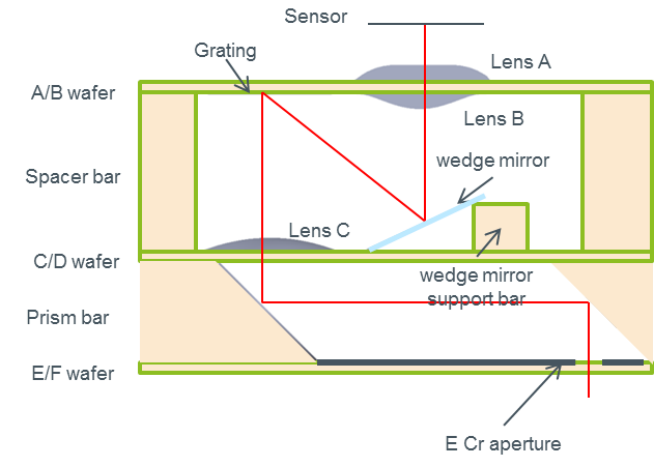
(*) PPG: optically obtained plethysmogram (**) ECG: electrocardiography

Spectrometry – bringing the lab to the sample

Miniaturized spectrometer for industrial, medical and consumer applications



Lab to the
sample



Optical spectrometry trends

Measuring physical parameters on the go drive the demand for miniaturization of spectroscopy:

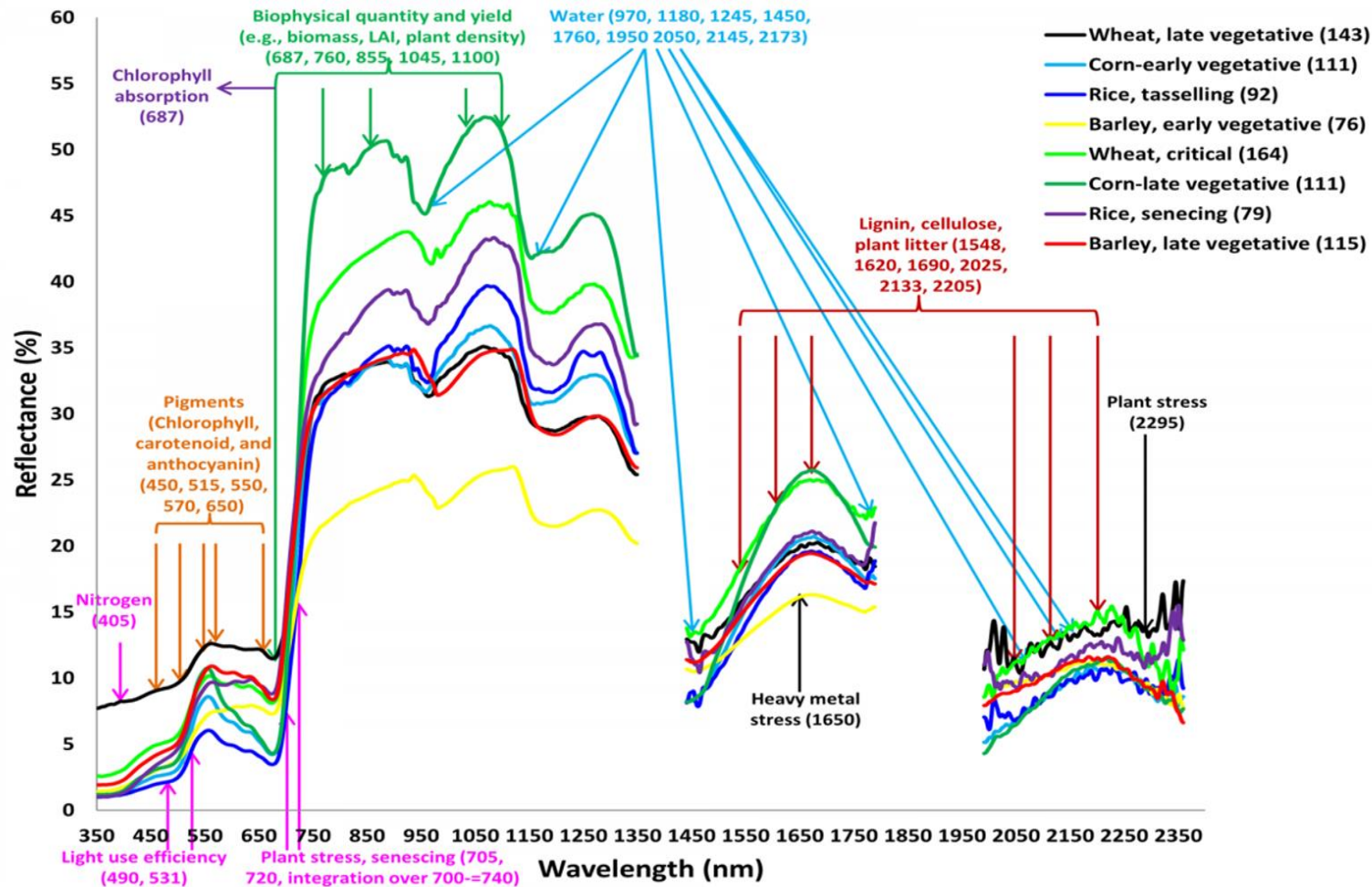
- Food safety and authenticity
- Calorie intake
- Material recognition or gas analysis
- Medical probes
- Agriculture

ams vision & solutions

- Optical spectral sensors will enable new use cases for mobile as well as for related medical and industrial applications
- Folded grating-based optics, all in one modular solution
- Single-slit: less sensitive to intensity and spectral distribution on target
- Technology and roadmap will develop from visible and NIR range to MIR spectroscopy allowing to „see more“

Spectrometry – bringing the lab to the sample

High resolution NIR spectrometer



Next frontier applications



Agriculture analysis

Enabling the digital transformation

Focused sensing strategy, driving next frontier applications

Leadership



Optical



Imaging



Environmental

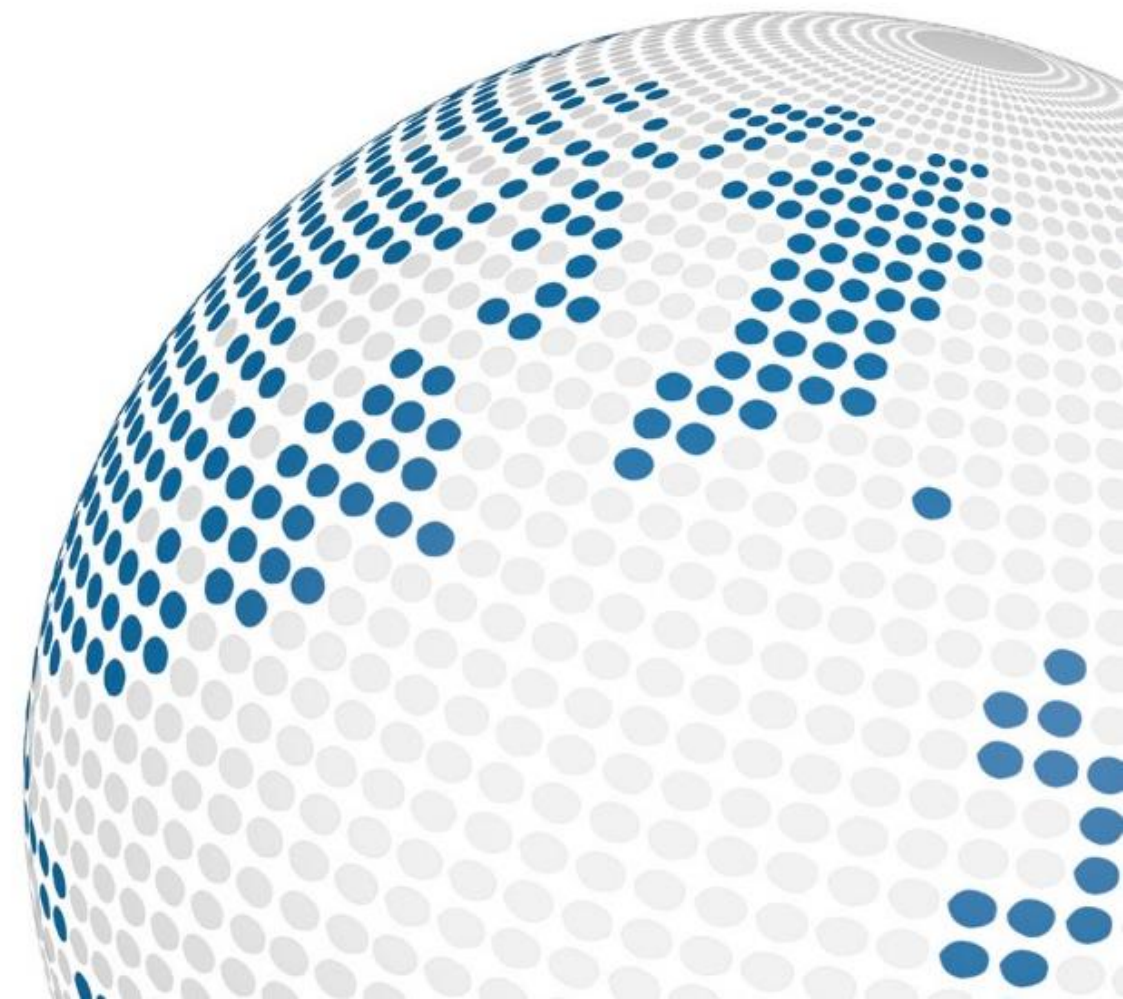


Audio



Manufacturing strategy

Mike Lusk
EVP Operations & Supply Chain Management



ams scalable manufacturing strategy

Differentiating capability in-house and outsource standard processes



In-house wafer manufacturing, Austria

- 200mm capacity, 180-190k wafers p.a.
- CMOS/specialty analog down to 180nm
- High volume optical filter deposition line

In-house optical packaging, Singapore

- Technology leader in high-end optical packaging
- Major capacity expansion driven by customer volume requirements
- Further capacity expansion and new VCSEL manufacturing investment



In-house test, Austria / Philippines

Technology partnerships for scalability and flexibility

- High volume wafer production: TSMC and UMC
- Standard and semi-custom packaging: Hana, Amkor and ASE
- Partnerships with key equipment suppliers

ams manufacturing footprint



Ang Mo Kio, Singapore

- 7,000+ employees
- 30,000 m²
- Wafer level optics, packaging



Woodlands, Singapore

- 600+ employees
- 10,000 m²
- Wafer level optics



Tampines, Singapore

- 100+ employees
- 15,000 m²
- Optical filter, VCSEL, wafer test



Graz, Austria

- 400+ employees
- 7,500 m²
- ASIC, TSV, optical filter



Calamba, Philippines

- 600+ employees
- 7,500 m²
- Test, sensor calibration

Ability to support fast ramps

October 2016



April 2017



July 2017



November 2017



Successful ramp of our AMK facility, supporting our 2017 revenue growth

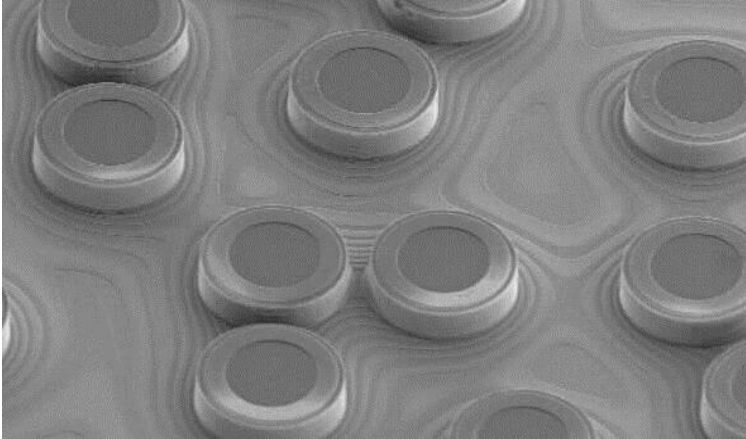
- Implementing the expected steep ramps of new optical solutions
- Quickly moving to very high run rates

Ramping in 9 months

- From 1,200 FTE to over 8,000 FTE
- Fitting clean room from 5,000 m² to 30,000 m²
- From zero to 3,400 pieces of equipment

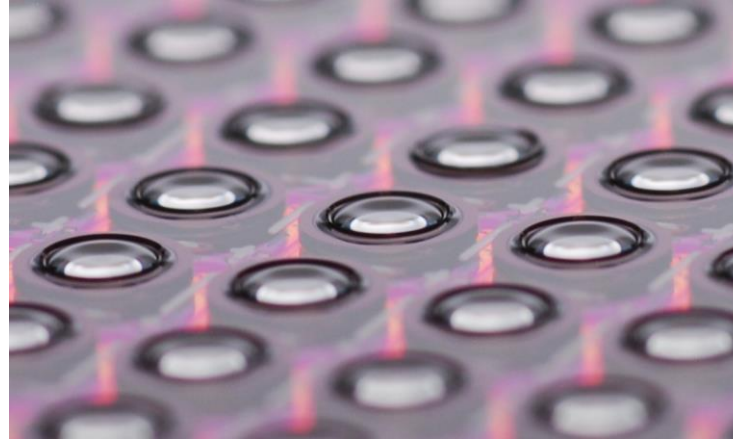
Highly differentiating processes

Protecting our specialized process know-how



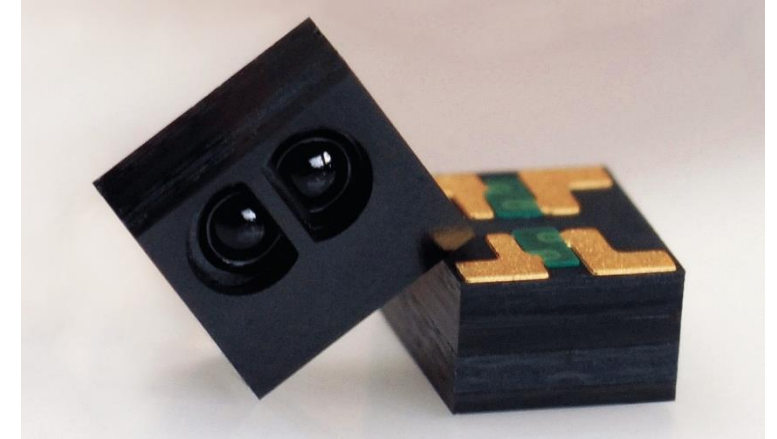
Wafer manufacturing

- Application-specific ICs (ASIC) in special CMOS processes
- High-power VCSELs



Wafer post-processing

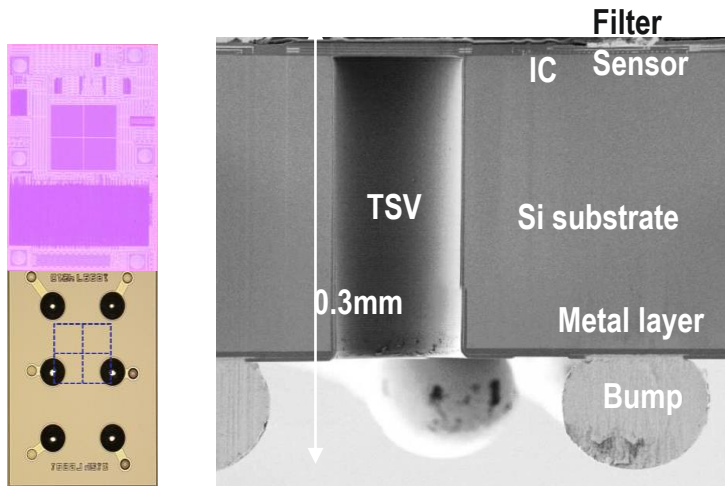
- Wafer Level Optics (WLO)
- Interference filters
- Open tube TSV last (Through Silicon Via)
- Monolithic integrated MEMS (i.e. pressure sensor)



Assembly, calibration and test

- Diffractive Optical Element (DOE)
- Vacuum Injection Molding (VIM)
- Micro-optical modules
- Sensor calibration and testing

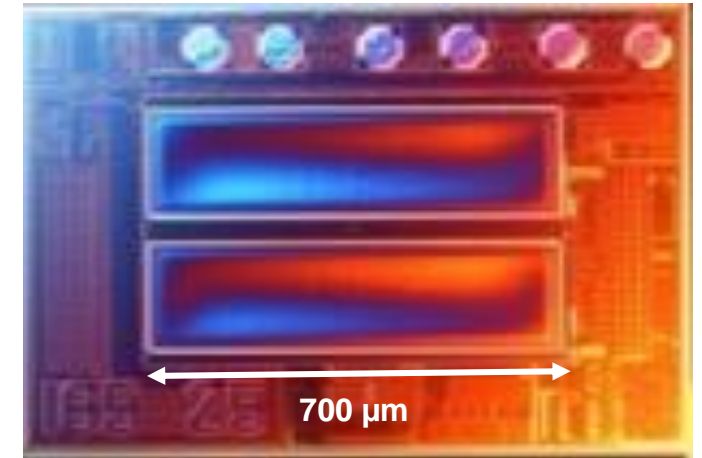
Enabling differentiating products



**Wafer level integrated
ambient light sensor**



**Wafer level stacking of optical
elements**



**Monolithic integrated
atmospheric pressure sensor**

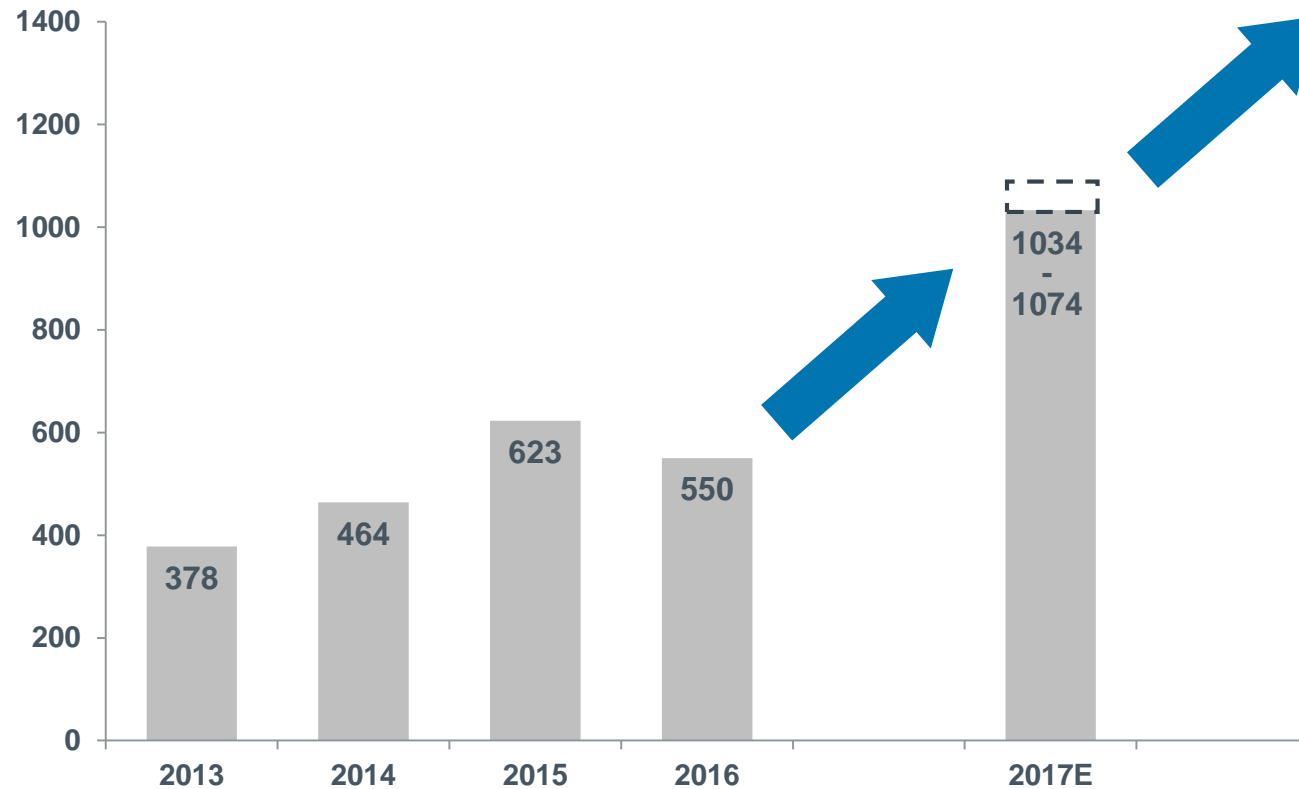
Financial performance & outlook

Michael Wachslar-Markowitsch
Chief Financial Officer



Revenue growth acceleration

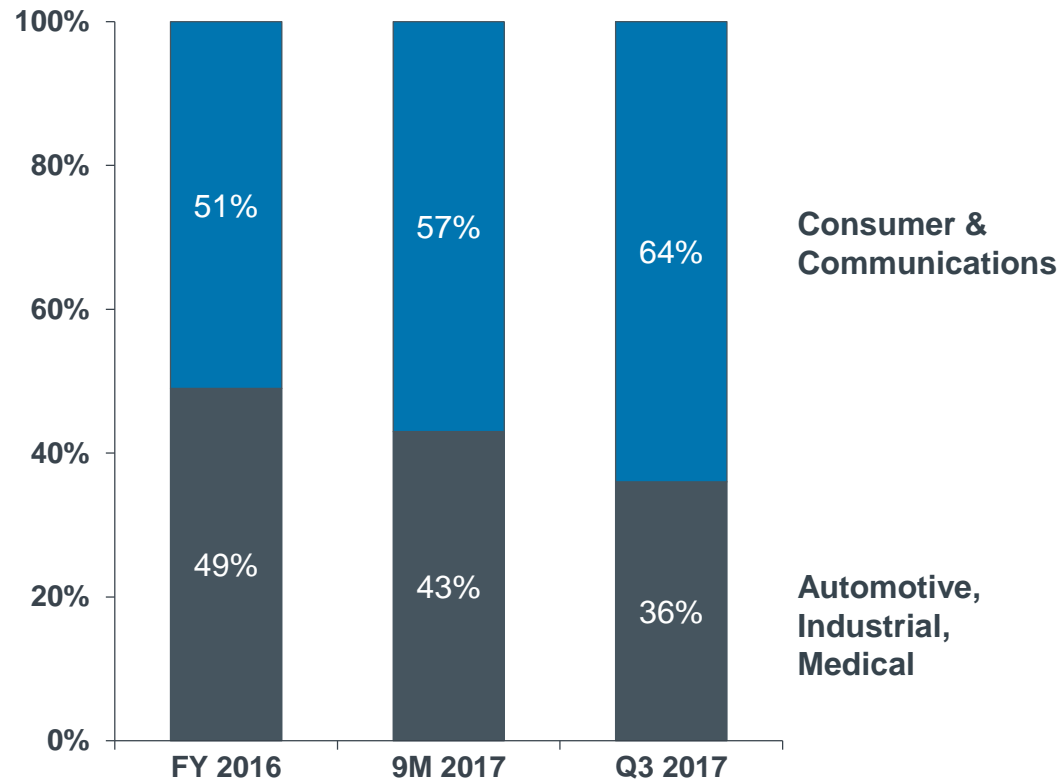
Group revenues (EURm)



Significant acceleration of revenue growth trend

- Achieving EUR1bn+ in 2017
- Fully validates focused strategy
- Successful growth platform based on strategic acquisitions
- Large scale wins and focus on major opportunities drive revenue expansion

Revenue distribution



Revenue distribution trend to reflect strong C&C growth

- C&C predominant growth driver over coming years
- C&C share expected to exceed historic 65% mid-term
- Long-term target of 60/40 C&C/AIM

Multiple layers of diversification

- Broader product set in largest customers
- Broader customer base in key end markets
- Broader range of end market applications

Two distinct financial models

	C&C target model	AIM target model
Revenue growth CAGR 2016-2019 (%)	Total higher than 40	
Gross margin (%)	Low to mid 40s	Mid to high 50s
R&D (%)	Around 10	Mid to high teens
SG&A (%)	Mid single-digit	Low teens
Adj. EBIT (%)	~30	~30

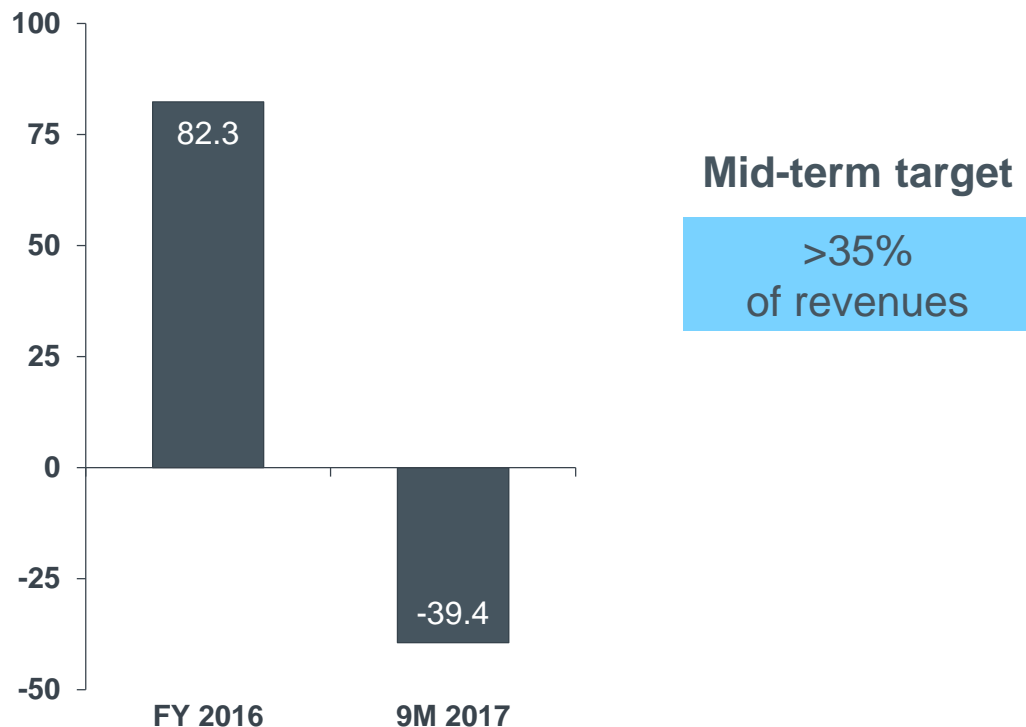
Growing earnings for shareholders

Company model comments

- Acquisition-related amortization:
Approx. EUR 80m p.a. currently
- Adjusted EBIT excludes
acquisition-related and share-
based compensation costs
- Group tax rate:
Mid-term expectation of
well under 10%

Financial model: Operating cash flow

Operating cash flow (EURm)

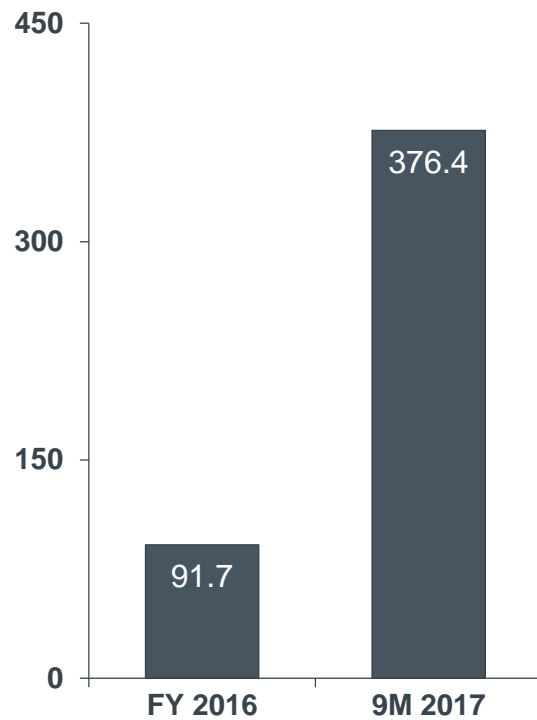


Strong cash flow generation ahead

- FY 2016 14.4% of revenues
- 9M 2017 -6.6% of revenues
- 9M 2017 negative operating cash flow mainly driven by capacity investments and related depreciation
- Expected strong increase in cash flow from Q4 2017 onwards
- 2018 operating cash flow expected to support ongoing CAPEX, dividend payment and share buy-back

Financial model: Capital expenditures

Capital expenditures (EURm)



Long-term target

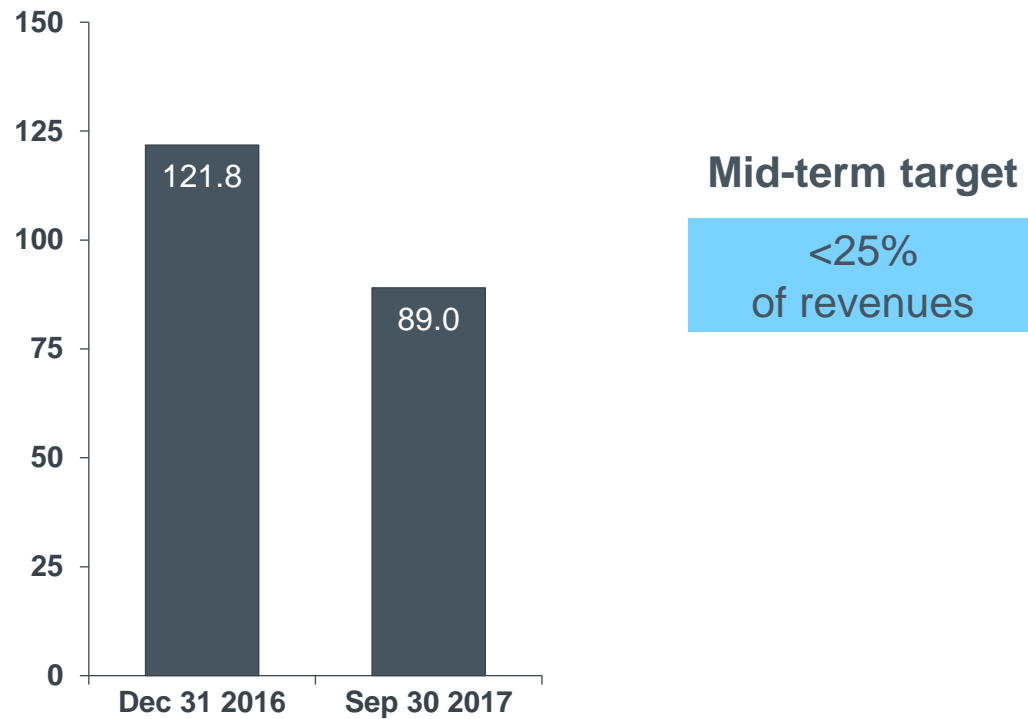
10-15%
of revenues

Expected peak capital expenditures in 2017

- FY 2016 16.7% of revenues
- 9M 2017 63.4% of revenues
- Increase driven by major capacity build in Singapore to support 2017 ramps and 2018 plans
- Targeting meaningfully lower capex for 2018 based on current information

Financial model: Working capital

Working capital (EURm)



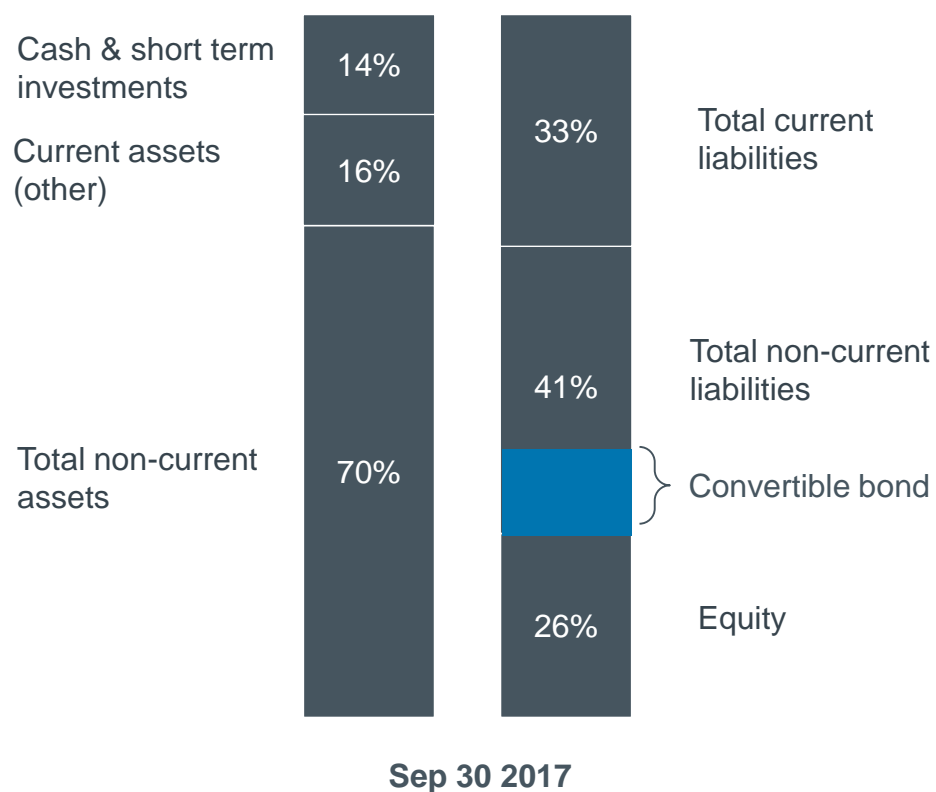
Balancing working capital management and growth

- FY 2016 22% of revenues
- 9M 2017 15% of revenues
- Higher WIP needs given internal capacity expansion
- Revenue distribution trend with outsourced wafer production helps balance working capital needs

Calculated as trade receivables + inventories - trade liabilities

Capital structure: Balance sheet

Balance sheet



Current elevated leverage due to investments and convertible bond accounting

- Increasing equity ratio expected for 2018 resulting from strong profitability
- Average interest rate total debt 2017E <1%
- Comfort level up to 3x net debt / adj. EBITDA

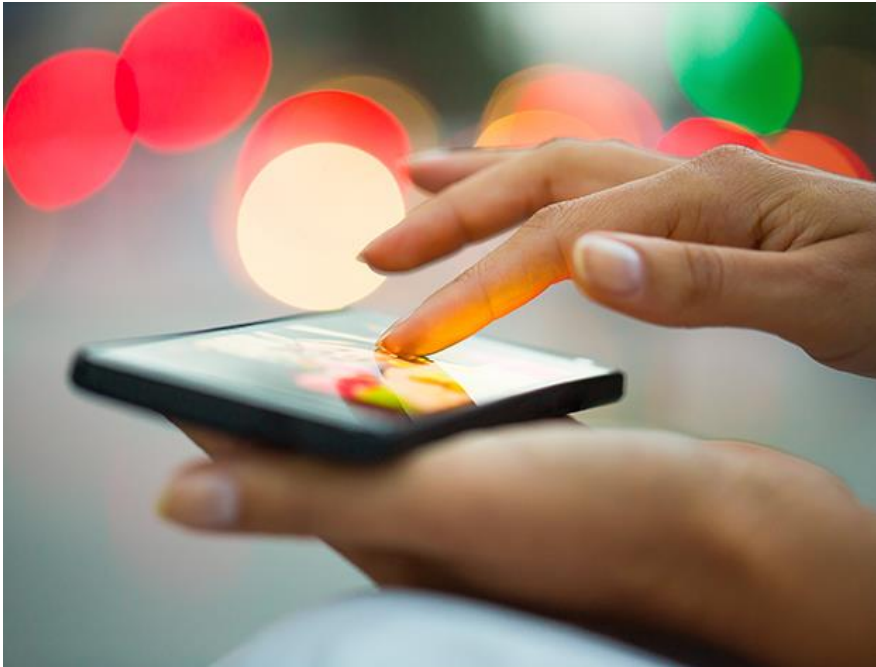
Convertible bond

- USD 350m issued end of Q3 2017
- Foreign currency issuance IFRS accounting treatment:
 - Changes in value of option component due to share price change must be fully recognized in financial result
 - Total amount of convertible bond recognized as debt
- To adjust for effects, adjusted net result and EPS from Q4 2017 onwards

Capital return policy

Share buy-back	Dividends
Running authorization until October 2019	Paid after June AGM
Total capital return 3yrs EUR 229m (9m 2017)	Total capital return 3yrs EUR 82m
Ongoing buy-back, potential uses: SOP coverage, strategic transactions, cancellation	2017 0.30 EUR per share
2017/2018 special situation: buy-back of approx. EUR 154m (3.8m shares) in Q4 2017/Q1 2018 via collar to cover potential share portion of Heptagon earn-out	Plan to realize increases based on business performance with no decreases vs. previous year
2018 expected to continue on comparable level (ex-Heptagon special situation)	

Sound financial model for growth



- Profitable growth company with a sound financial model
- Strong cash flow serves our capital expenditure and operational needs and enables capital return
- Use leverage as a tool to support and accelerate our strategy, particularly via M&A