Optical Sensing Solutions Introduction

Jean-Marc Leang & Robin Ran
Imaging
AP Region, STMicroelectronics
1. Quick Imaging introduction
2. FlightSense™ introduction
3. FlightSense™ Mass Market use-cases & examples
End market focus & ST product families

IMG portfolio delivering complementarity for ST target end markets & synergies in R&D and manufacturing

- Dedicated Automotive ICs
- Discrete & Power Transistors
- Analog, Industrial & Power Conversion ICs
- MEMS & Optical Sensing Solutions
- Digital ASICs
- General Purpose & Secure MCUs EEPROM
Imaging & Optical Sensing Solutions
20+ years offering innovation to market

Creation of VISION
Start-up from
The University of Edinburgh

The University of Edinburgh
Initiates work in CMOS Sensor
Early paper on CMOS Imaging

STMicroelectronics acquired VISION
Imaging Division
Creation


1M camera module & ISP shipped for mobile
500 Millions ISP shipped
Time-of-flight Ranging sensor ramp-up
ST 1st ALS product launched
New Global Shutter image sensor family

From traditional RGB Imaging for handsets to strategic refocus on key fast-growing applications
Strong ramp down of commodity Camera Module
Deployment of Time-of-Flight Solutions
Strong ramp of Time-of-Flight Solutions
Deployment of Specialized Imaging Sensors
Expansion toward new applications & use-cases

Large volume camera proliferation in Nokia camera phones
Start customers & applications diversification
FlightSense* pervasion in smartphones
1Bu FlightSense* shipped
Proliferation in smartphones, PC & Mass Market

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Optical sensing solutions for Industrial

Time-of-Flight sensors & Global shutter image sensors for multiple applications and use-cases

All-in-one Time-of-Flight modules
Longer ranging, wider field-of-view

Time-of-Flight 3D sensors
Higher resolution, depth-map

Global Shutter image sensors
2.6 µm down to 2.2 µm pixel

Ambient Light Sensors
Small size, low power, flicker detect
FlightSense™
Time-of-Flight
proximity and ranging sensors
FlightSense* technology

True distance measurement
Independent of target size, color & reflectance
Fast and low power
Truly invisible 940nm illumination

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Time-of-Flight Principle

Measured distance = Photon travel time / 2 x Speed of light

1cm round-trip takes 67ps
ST is #1 Worldwide Time-of-Flight sensor supplier

5 Generations
of all-in-one ToF solutions deployed since 6 years

>50 OEMs
Over 200 phones with ST’s Time of Flight technology
Several hundreds of non wireless end products on the market
Unlimited variety of use-cases beyond smartphones

>47,000
Evaluation kits deployed

1 Billion
ToF units shipped in November 2019, high volumes continuing.
Mastering end-to-end supply chain
FlightSense™
Typical module overview

All-in-One (illumination & sensor) Time of Flight System
Optimized Size, Performance, Cost mix

- Monolithic ToF SoC, SPAD Array, RAM/ROM & high safety Class 1 VCSEL driver
- Advanced optics with integrated IR filters
- State-of-art assembly & testing
- ST manufacturing line in Shenzhen
- Full Class 1 safety high efficiency VCSEL
- All FlightSense™ products are Laser Class 1 certified, to typically higher standards than competitors

- IEC/EN Class 1 laser product certified:
  - For both 60825-1 2007 and 2014 editions
  - Under all operating conditions
  - Under single-fault failure conditions
  ➔ SAFEST laser class
Smart optical sensing & FlightSense™ … making light work

- **Camera Assistance**
  - Laser autofocus
  - Touch-to-Focus
  - Scene understanding
  - AWB assist based on 940nm content

- **Ranging & Proximity**
  - True ToF distance
  - High accuracy
  - Up-to 4 meters

- **Multispectral & Flicker**
  - True tone color display & ALS
  - Camera AWB
  - Light flicker measurement and correction

- **Face Identification**
  - Face anti-spoofing
  - Cost, power, size optimized
  - All-in-one depth sensing

- **Presence, User Detect**
  - Security
  - Comfort
  - Power saving
  - Eye protection
  - Wellness

- **Depth Map & AR/VR**
  - All-in-one Module
  - High resolution receiver
  - Gesture
  - Consumer LiDAR
FlightSense™ product portfolio
FlightSense™ mass-market roadmap

**NEW**

- XX° FoV
- Programmable FoV
- XX° Max
- Up to 4 zones sequentially
- Up to 64 zones
- Histogram
- MultiObject detection
- Perf. Under Ambient
- Smudge correction
- Close distance
- Linearity
- Ambient Light Sensing

**Overall performance**

1. **VL6180V1** (Gen1)
   - Available NOW
   - In MP
2. **VL53L0CX** (Gen2)
   - Available NOW
   - In MP
3. **VL6180X** (Gen1)
4. **VL53L5CX** (Gen4)
   - New MPQ1 Samples NOW
5. **VL53L1CX** (Gen3)
   - Available NOW
   - In MP
6. **VL53L1CB** (Gen3)
   - Available NOW
   - In MP

Max. Distance measurement in cm (in the dark)

- 100cm
- 200cm
- 300cm
- 400cm
- 500cm
- 600cm
- 700cm
- 800cm

- 300cm

**Program features**

- XX° FoV
- Programmable FoV
- XX° Max
- Up to 4 zones sequentially
- Up to 64 zones
- Histogram
- MultiObject detection
- Perf. Under Ambient
- Smudge correction
- Close distance
- Linearity
- Ambient Light Sensing

**Longevity commitment**

- 7 years
A wide FlightSense™ portfolio ready to meet unlimited market and application requirements

<table>
<thead>
<tr>
<th>FlightSense™ portfolio</th>
<th>VL6180X</th>
<th>VL6180V1</th>
<th>VL53L0CX</th>
<th>VL53L1CX</th>
<th>VL53L3CX</th>
<th>VL53L1CB</th>
<th>VL53L5CX</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Proximity sensor</strong></td>
<td>Proximity sensor + Ambient Light Sensor</td>
<td>Proximity sensor</td>
<td>Ranging sensor</td>
<td>Programmable FoV ranging sensor</td>
<td>Proximity + Multi target ranging sensor</td>
<td>Long Distance + Multi target ranging sensor</td>
<td>Multizone sensor + wide field of view</td>
</tr>
<tr>
<td><strong>Distance measurement</strong></td>
<td>Proximity up to 60 cm</td>
<td>Proximity up to 60 cm</td>
<td>Ranging up to 2 m</td>
<td>Ranging up to 4 m</td>
<td>Proximity + ranging up to 5 m</td>
<td>Long distance ranging, up to 8 m</td>
<td>Mini depth map up to 4 m</td>
</tr>
<tr>
<td><strong>Resolution</strong></td>
<td>1 zone</td>
<td>1 zone</td>
<td>1 zone</td>
<td>1 zone</td>
<td>1 zone</td>
<td>1 zone or sequential Multi-zone</td>
<td>64 Zones 8x8 or 4x4</td>
</tr>
<tr>
<td><strong>Field-of-View</strong></td>
<td>25° No Lens</td>
<td>25° No Lens</td>
<td>25° No Lens</td>
<td>27° (SW configurable) Lens on Rx</td>
<td>25° No Lens</td>
<td>27° (SW configurable) Lens on Rx</td>
<td>61° Lens on Rx Lens on Tx</td>
</tr>
<tr>
<td><strong>Multi-target detection</strong></td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Small all-in-one modules</strong></td>
<td>4.8 x 2.8 x 1.0 mm</td>
<td>4.8 x 2.8 x 1.0 mm</td>
<td>4.4 x 2.4 x 1.0 mm</td>
<td>4.9 x 2.5 x 1.56 mm</td>
<td>4.4 x 2.4 x 1.0 mm</td>
<td>4.9 x 2.5 x 1.56 mm</td>
<td>6.4 x 3.0 x 1.5 mm</td>
</tr>
</tbody>
</table>
FlightSense

VL53L1CX System FoV (Field of View)

Compatible VL53L0CX, VL53L3CX & VL53L1CX footprint allowing flexibility and easy migration

VL53L1CX

- OLGA12 Package
- XY Dimensions: 4.9 x 2.5 mm
- Z Height: 1.56 mm +/- 40um (max 1.6mm)
- Re-flowable (IPC/JEDEC JSTD-020-C)
- Includes 30° lens on the return aperture
- Lens increases return signal reaching SPAD sensing array x8 versus VL53L0CX
- Increased ranging performance and accuracy as a result
- No lens on the VCSEL emitter
- Emitted optical power is identical to VL53L0CX
- Full laser class1 certification

Typical System Field of View: 27°
FlightSense™

Detection Cones & Optical Field-of-view (FoV)

Extended ranging distance enables (very) large target detection area, to be fit application by application

Diagonal Field-of-View = 27°
Programmable Region of Interest (ROI) enables flexible Field of View (FoV) on VL53L1CX/CB

VL53L1CX - ROI application note
(AN5191 on st.com)

<table>
<thead>
<tr>
<th>ROI zone size</th>
<th>Virtual Diagonal FOV coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>4x4 spads</td>
<td>15° (smallest)</td>
</tr>
<tr>
<td>8x8 spads</td>
<td>20°</td>
</tr>
<tr>
<td>16x16 spads</td>
<td>27° (largest, full FoV)</td>
</tr>
</tbody>
</table>
FlightSense™
Industrial applications
FlightSense™ main sensor functions

Enabling multiple use-cases:

- Ceiling detection
- Content analysis
- Cliff detection
- Gesture control
- Hands-free operation
- Light control
- Load management
- Object detection
- Obstacle avoidance
- Occupancy detection
- Parking occupancy
- Presence Detection
- People counting
- People counting
- Power saving
- SLAM
- Touch-less operation
- Volume control
- Wall tracking

To develop an unlimited number of markets...
Unlimited markets & applications

- Laptops
- Printers
- Tablets
- Public parking
- Cleaning robots
- Service robots
- Toys
- Drones
- Industrial
- Smart home
- Logistics
- Vending machines
- Lockers
- ATM
- AR/VR
- Wearable & IoT
- Faucets
- Medical
- Farming
- Trucks
- Projectors
- White goods
- Dispensers
- Warehouse
- Tanks
- Lighting
- Farming
- Laptops
- Lighting
FlightSense™
Focus on proximity sensing

Low-power mode & small footprint enabling best user experience

Typical applications

- Home appliances & Smart Home
- Sanitary systems & premises
- Educational tablets & child smart glasses
- Home automation controls, displays & smart switches
- Touchless systems
- Smart Parking
- Smart Farming

Core benefits

- Performance proven for challenging industrial designs
- High IP integration ready
- Immune to color and texture
- Works with many optical cover materials
- Volume (or else) control
- Small footprint
- Cost-effective system
Focus on cleaning robots & service robots

Supporting multiple functions in one robot

Typical applications

- Obstacle avoidance
- Wall tracking
- Cliff or ceiling detection
- Touchless operation

Core benefits

- Low-power environment sensors
- Performance proven for challenging industrial designs
- Multiple sensors in one robot for ease of integration
- Low memory footprint
- Cost-effective systems
FlightSense™
Focus on access control / Presence detection

Full product range from close distance to 8 m detection

Typical applications
- Home appliances
- Access control systems
- Smart speakers
- Smart displays & panels
- Home automation controls, displays & switches
- Occupancy detection
- Touchless systems

Core benefits
- Immediate presence detection
- Effective ON/OFF saving power
- Accurate distance measurement
- Added value features
- Multiple maximum distance offer
- Small footprint
- Cost-effective system

Recommended products: VL53L0CX, VL53L3CX, VL53L1CX/CB & VL53L5 (new)
FlightSense™
Focus on factory automation

A wide range of sensors ready for flexible multi-usage integration

Typical applications
• Conveyor belts
• Safety curtains
• Rolling machines
• Logistics management
• Bar-code readers
• People counting

Core benefits
• Long distance ranging
• Multi-object detection
• Fast ranging mode (100 Hz)
• Configurable FoV (RoI)
• High accuracy
• Smudge resistance
• Liquid level detection
• High sensor count integration
• Low power
FlightSense™ use-cases COVID19 opportunities

Social distancing
- Accurate distance measurement
- Keeping safe distance between people in public spaces

Content management
- Inventory control
  - Check how many masks remain
- Monitoring in real time
  - Avoiding empty stock

Liquid level management
- Liquid level control
  - Gel tank level management
- Real time monitoring
  - Avoiding empty tank

Mask dispenser

Touchless Human Machine Interface
- Presence detection
  - Turn on equipment when someone is present
- Touchless Buttons
  - Basic gesture recognition
    - Avoid contact with screen

Touchless buttons
- Basic gesture recognition
  - Contact less door operation

Presence detection
- Presence detection
  - Turn on/off the thermometer if a user is detected
- User distance Control
  - Ensuring user is at the right distance

Public display
- Access Control
  - Presence detection

Thermometer
- Thermal camera
- Access Control

Public transportation
- Basic gesture recognition
  - “zero-touch” operation

Hydro alcoholic gel dispenser

Proximity detection
- Basic gesture recognition

People counting
- Counting entry/exit
  - Respecting maximum number of people authorized in premises

Shop/Restaurant entrance

1.8m

Social distancing awareness

Counting entry/exit
Respecting maximum number of people authorized in premises
High Performance  Small Footprint  
Global Shutter Sensor
Global shutter sensors
Main machine vision use-cases

**Depth Sensing**
- Active Stereo
- Structured Light

**Biometrics**
- Windows Hello
- 2D Face ID
- Gesture detection
- Human detection
- Iris recognition

**AR/VR/MR**
- Eye-tracking
- 6DoF
- SLAM

**Robotics & Machine Vision**
- Drone
- SLAM
- Scene analysis
- Object detection
- Barcode
Analogue to Digital conversion time

Integration time

Global Shutter sensors

Why global shutter

Rolling Shutter

Global Shutter

Rolling Shutter

Exposure line after line, with a delay

Global Shutter

All lines exposed to the light at the same time

Near IR illumination

- Illumination power consumption
- Eye exposure to Near IR

Global Shutter

1/10 power decrease

1/10 smaller eye exposure

Short illumination

Support moving camera & objects

Global Shutter

1000 lines

8us line 1
line 2
line 3

Integration time

8us line 998
line 999
line 1000

1000 x 8us = 8000us

1000 lines

8us

illumination ON

illumination ON

Pixel array integration time and read-out

Global Shutter

Rolling Shutter

1000 x 8us = 8000us

ON

800us

1000 lines

8us

line 1
line 2
line 3

illumination

800us

1000 x 8us = 8000us

1000 lines

8us

illumination ON

illumination ON

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• Illumination power consumption
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8us line 998
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1000 lines

8us

illumination ON

illumination ON

Pixel array integration time and read-out
Global shutter sensor for Industrial Main features

The smallest high performance 1.5mp and VGA + resolution global shutter sensor on the market

<table>
<thead>
<tr>
<th>2.6um Global shutter</th>
<th>VD56G3</th>
<th>VD55G0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resolution</td>
<td>1.5Mp</td>
<td>0.4Mp</td>
</tr>
<tr>
<td></td>
<td>1124x1364</td>
<td>644x604</td>
</tr>
<tr>
<td>Optical format</td>
<td>1/4”</td>
<td>1/9”</td>
</tr>
<tr>
<td>Optical Flow</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Dynamic Defect Correction</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Statistics</td>
<td>24x14 zones</td>
<td>8x8 zones</td>
</tr>
<tr>
<td>Auto-Exposure</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Frame contexts</td>
<td>4x</td>
<td>4x</td>
</tr>
<tr>
<td>Flexible IO</td>
<td>8x IOs</td>
<td>4x IOs</td>
</tr>
<tr>
<td>Sensor dimension</td>
<td>15.9mm²</td>
<td>6.5mm²</td>
</tr>
<tr>
<td></td>
<td>(3.6 x 4.3 mm²)</td>
<td>(2.6 x 2.5 mm²)</td>
</tr>
<tr>
<td>Mipi CSI-2 interface</td>
<td>2x 1.5Gbps</td>
<td>1x 1.2Gbps</td>
</tr>
<tr>
<td>Mirror/Flip, Crop, Binning (2x/4x)</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Temperature Sensor</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

- Disruptive pixel
- Global Shutter Pixel 2.6μm
- Small, High QE, PLS & FW, NIR perf
- BSI, Small X&Y, Full DTI, 40nm
- Silicon wafers, Stacking
- Advanced Process
- Compact
- Technology
- Small, High QE, PLS & FW, NIR perf
- BSI, Small X&Y, Full DTI, 40nm
- Silicon wafers, Stacking
- Advanced Process
FlightSense™
Takeaways
Key takeaways

*Time of flight, 3D sensing & global shutter image sensors: A wide product offer for Industrial applications*

- ST FlightSense™ leads in TOF product shipments, quality and services
- ST FlightSense™ provides true distance measurement independent of target color & reflectance
- ST FlightSense™ meets most stringent laser safety class 1 requirements
- A wide FlightSense™ product offering ready to meet unlimited markets & applications requirements
- ST offers high-performance **compact global shutter sensors** for machine vision applications
Thank you