



KMLabs

EUV Source Developments

Matt Harada, President

Henry Kapteyn, CTO



The Leader In Ultrafast

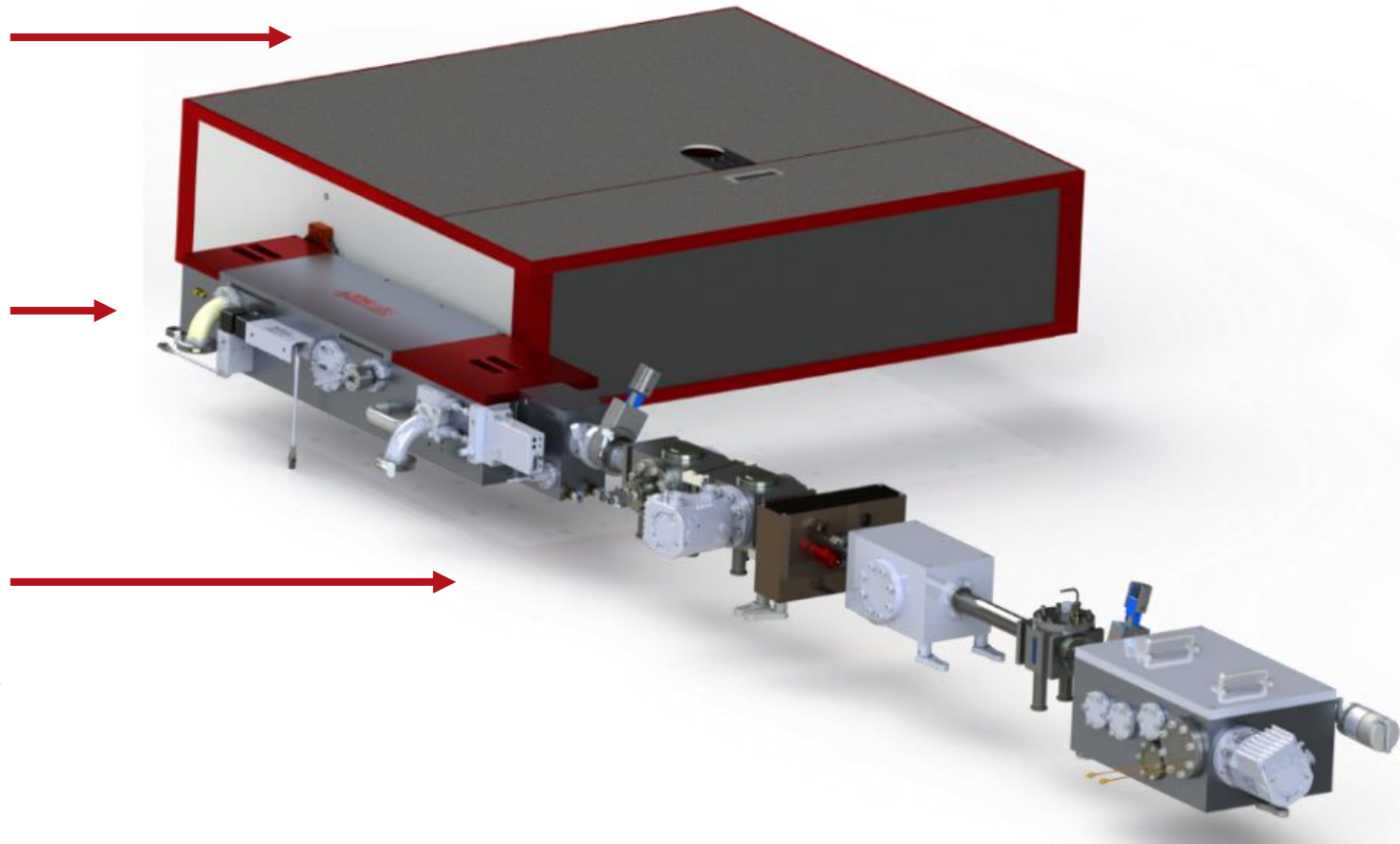
Founded in 2003 by award-winning scientists in ultrafast laser technology, KMLabs continues its legacy of innovation.

- 1st cryogenically-cooled ultrafast lasers
- 1st robust 10 femtosecond lasers
- 1st bright tabletop coherent EUV and soft X-ray beams
- >20 Patents
- 12 Science papers; 3 Nature papers; 6 Nature Photonics papers



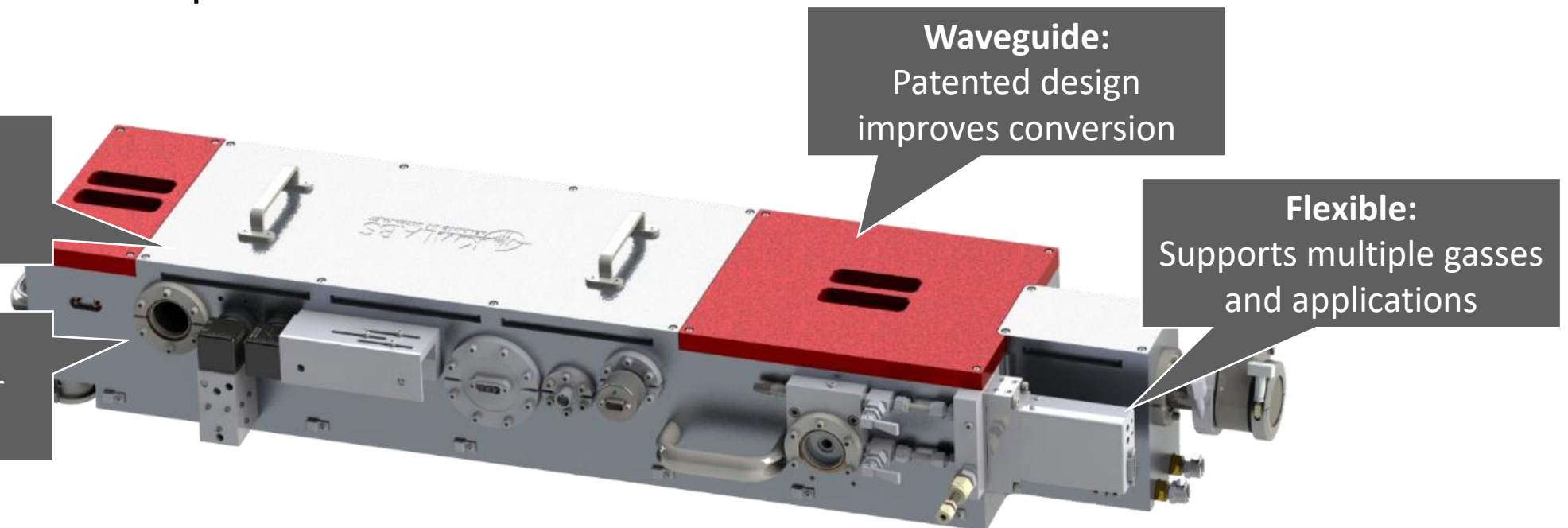
Pantheon™ EUV Source

- **RAEA™**:
Ultrafast Ti:Sapphire IR Laser
 - 800 nm 35 fs pulses
- **XUUS™** :
High Harmonic Generator
 - 28nm and 13.5nm
 - In demand for semiconductor applications
- **Arterium™** :
Vacuum Beamline
 - Modular components for EUV delivery



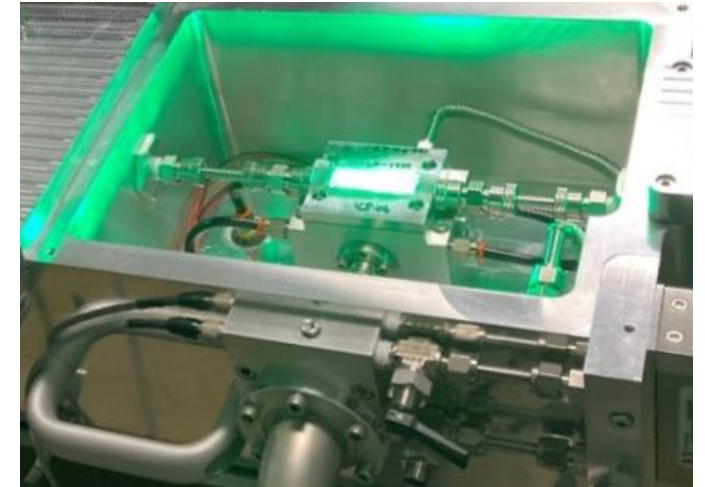
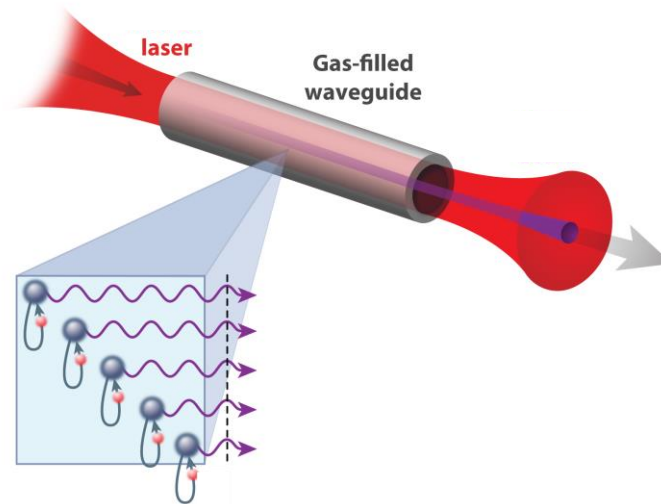
XUUS™ 5 High Harmonic Generator

The new XUUS 5 from KMLabs brings more stability and more flux to high harmonic generation of coherent EUV light in a tabletop form factor.

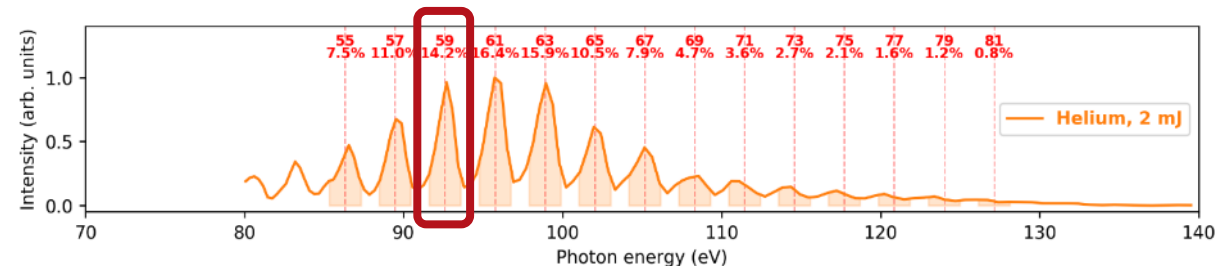


Unique XUUS™ Features

- Waveguide architecture permits better gas control and conversion efficiency
- Cartridge-mounted waveguide for ease of maintenance
- Produces coherent femtosecond EUV pulses



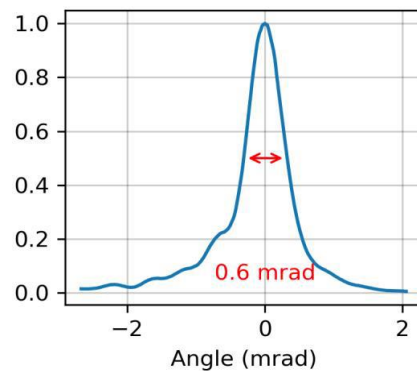
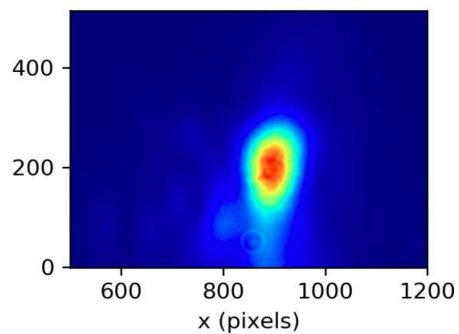
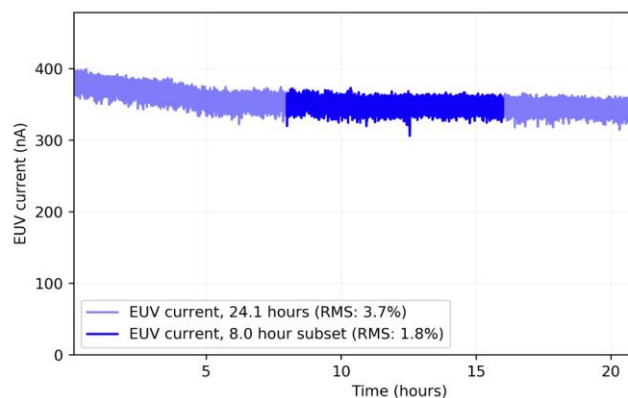
Helium for 13.5 nm EUV



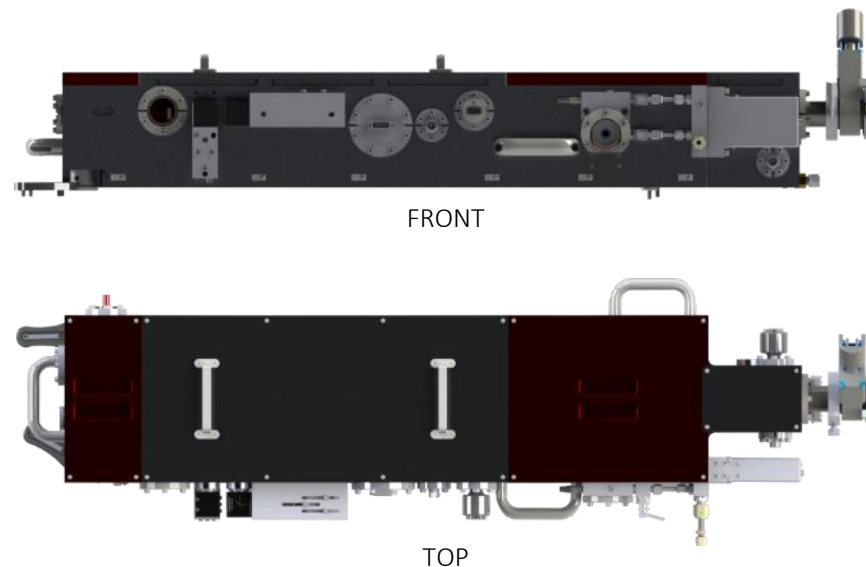
Performance

Improved flexibility,
stability, and flux

4 systems delivered so
far this year



Wavelength Range (for ~800nm pump)	~10 – 50nm
Flux	Up to 10^{12} ph/s/harmonic
Power stability of single harmonic	5% RMS
Dimensions (mm)	1200 L x 330 W x 176 H)



Robust Driving Laser Options

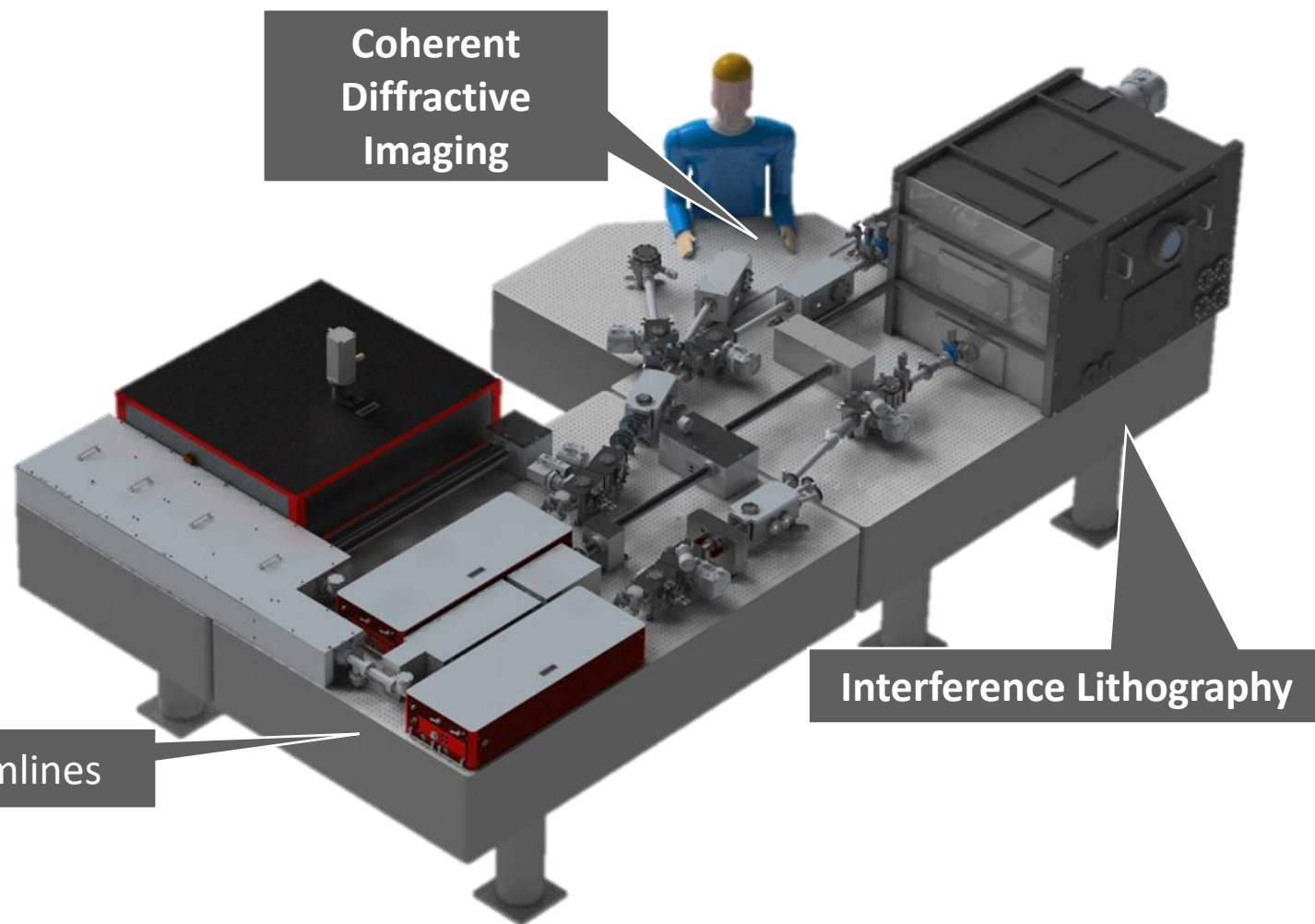
- Tested successfully with leading ultrafast lasers
- More flexibility
 - Maximize EUV flux with KMLabs RAEA with cryocooling
 - Strong per pulse performance with other popular lasers
 - Yb-based option offers high rep rates and stability up to 40 eV



Imec Collaboration

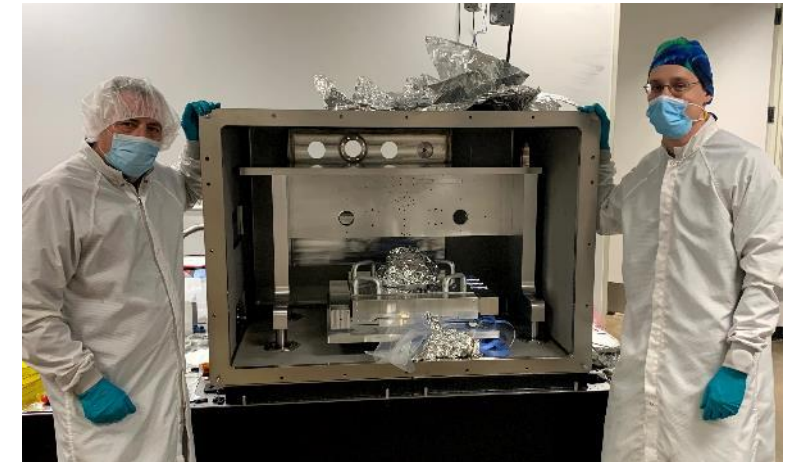
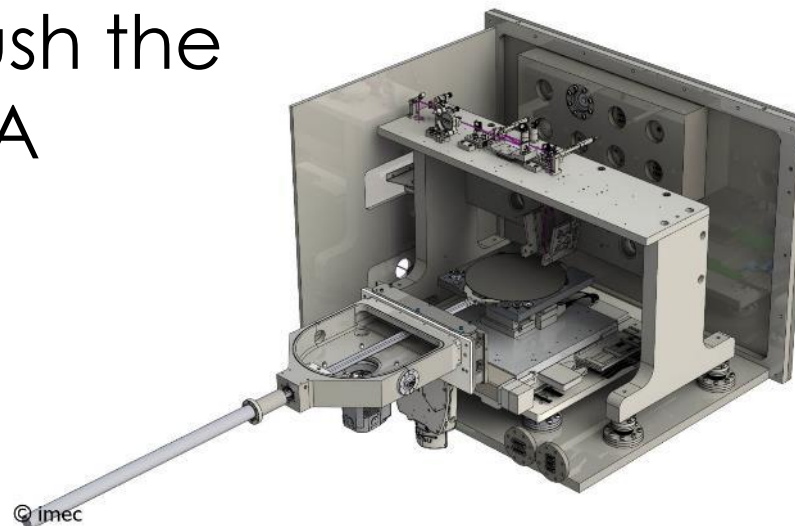
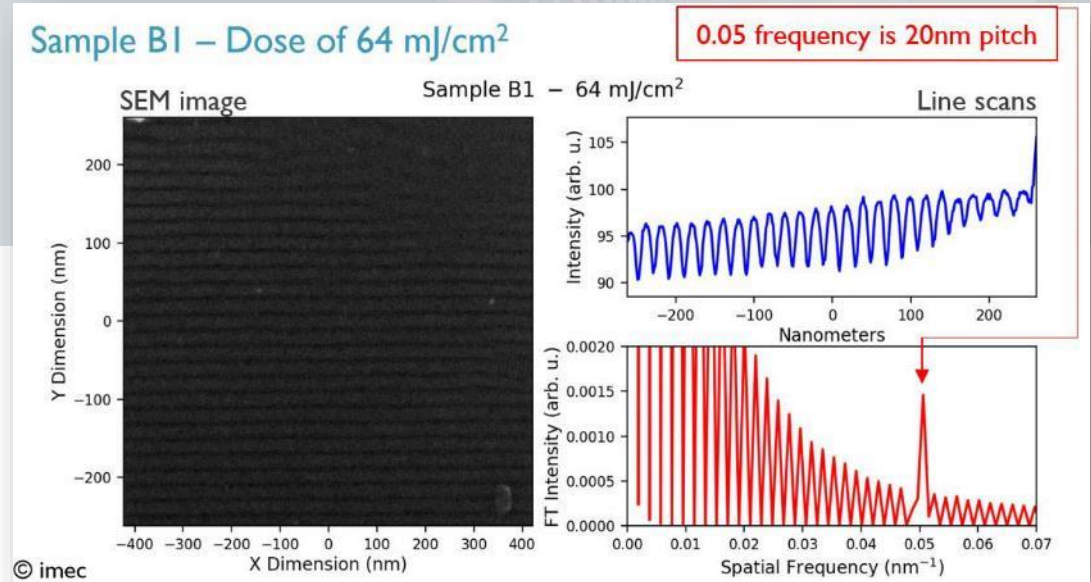
Joint development with imec is advancing semiconductor applications of the KMLabs EUV source

- Pump probe spectroscopy
- Interference lithography (IL)
- Coherent diffractive imaging (CDI)



IL Progress

- Successful initial proofs of concept for the KMLabs IL system
- Further implementation this year will push the limits of high-NA patterning

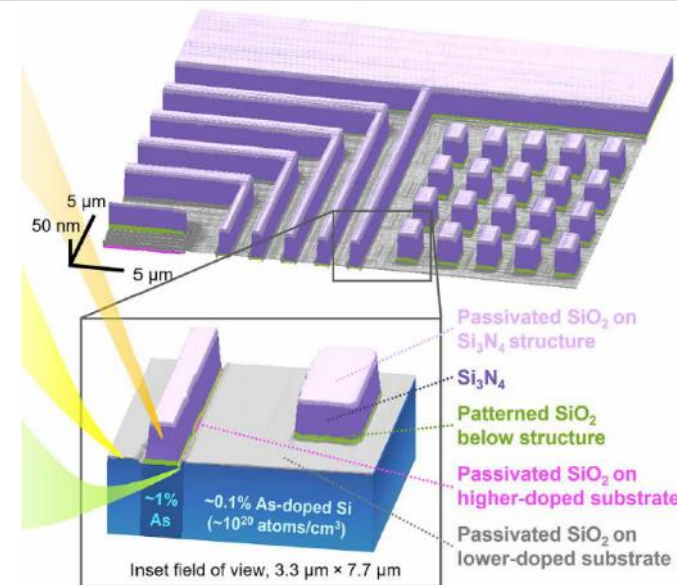


Coherent Diffractive Imaging

- HHG EUV source is ideally suited to actinic mask imaging
- Near the $\lambda/2$ resolution limits
- Development focused on detector speed and data processing

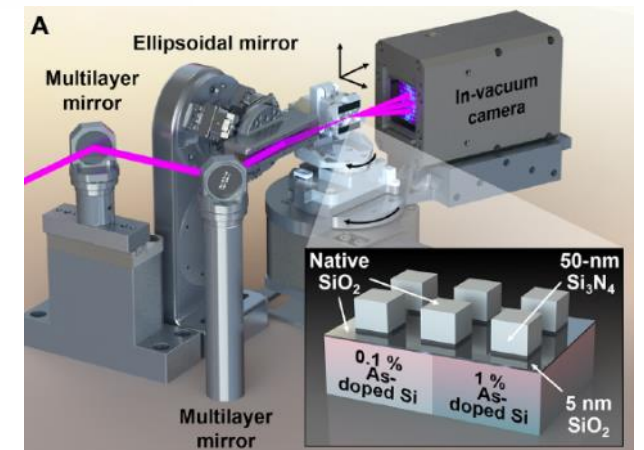
Demonstrations of results published in 2021

- **Modeling interface roughness** Esashi et al. "Influence of surface and interface roughness on X-ray and extreme ultraviolet reflectance: A comparative numerical study." *OSA Continuum* **4**, 1497 (2021)
- **Detecting defects with OAM light** Wang et al. "Coherent Fourier scatterometry using orbital angular momentum beams for defect detection." *Optics Express* **29**, 3342 (2021)
- **Reflectometer using IMEC sample** Tanksalvala et al. "Nondestructive, high-resolution, chemically specific 3D nanostructure characterization using phase-sensitive EUV imaging reflectometry." *Science Advances* **7**, eabd9667 (2021)



Spatially resolved, composition-sensitive, 3D nanostructure characterization

Amplitude- and phase-sensitive imaging reflectometer



Thank You

4775 Walnut St., Suite 102
Boulder, CO 80301

1-303-544-9068
sales@kmlabs.com
www.kmlabs.com