

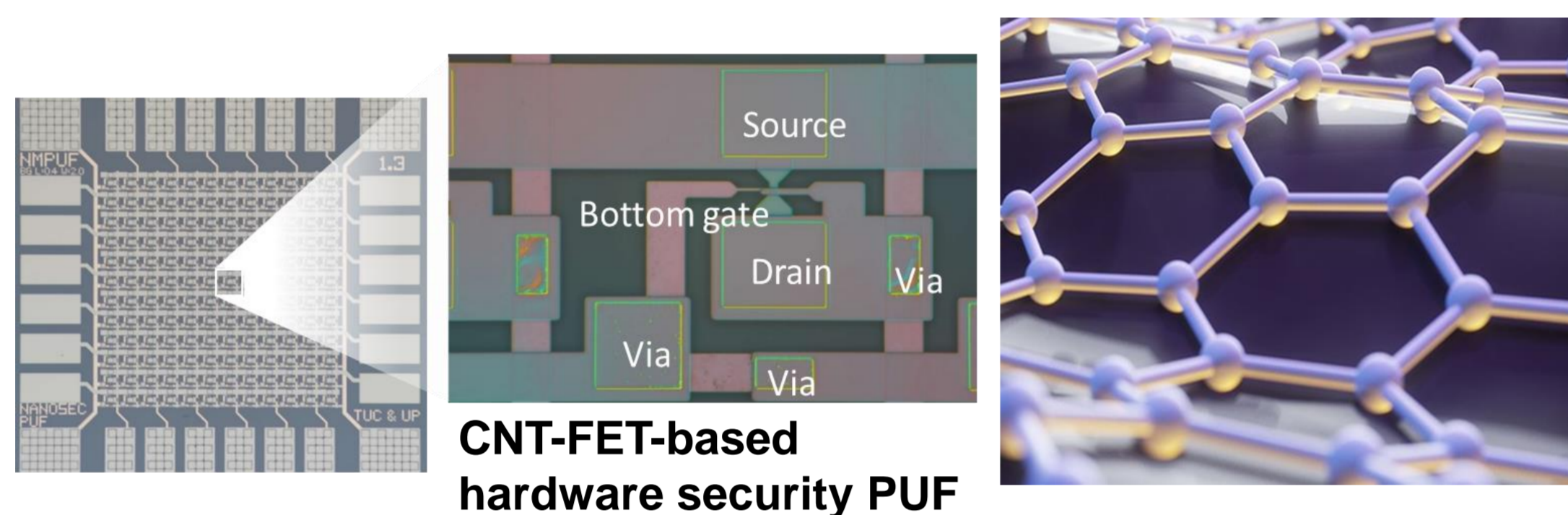
# Nano process technology for quantum technologies and photonics

## 1 Bottom-up nanopatterning integration 1D/2D

**Application:** Integrated 1D/2D nanomaterials in advanced quantum technologies for qubits, quantum sensors, light emitters, modulators, hardware security and cryo-electronics.

**Challenges:**

- Scalable heterogeneous integration of 1D/2D nanomaterials
- Component technology for operation at cryogenic temperatures
- Advanced structuring technology with minimal material influence, ultra-high quality, 3D architectures and heterogeneous material systems

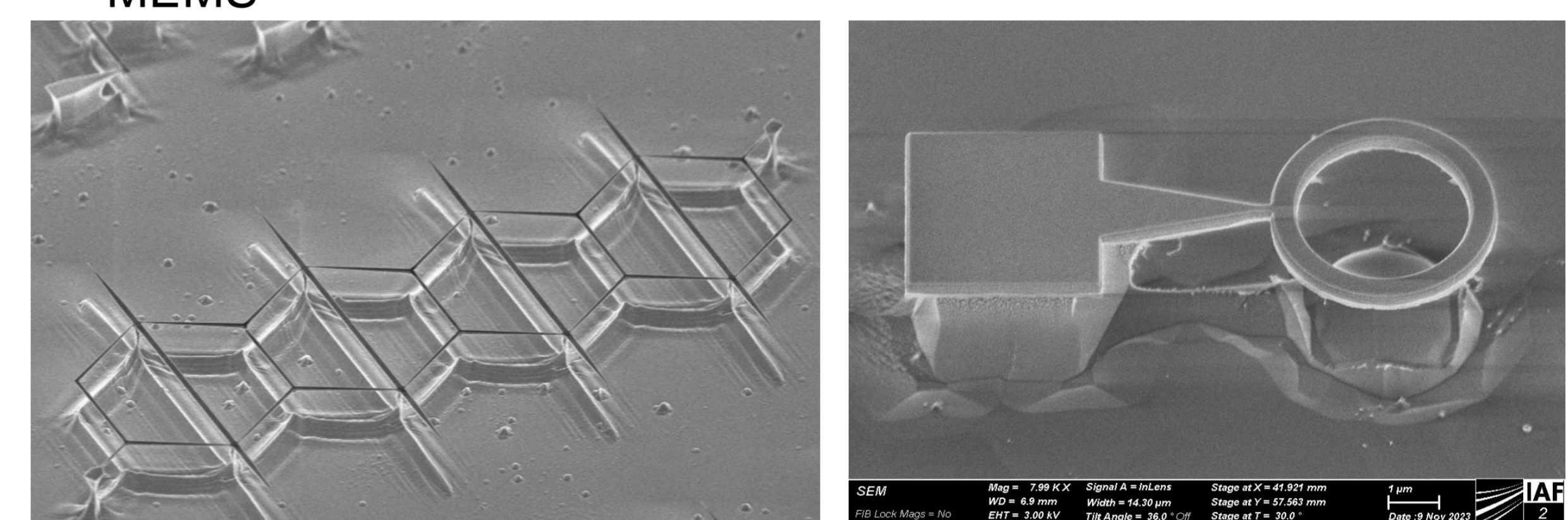


## 2 Nanostructures in diamond

Faraday cage angled-etching (FCAE) and isotropic etching enable the production of **free-standing diamond structures**

**Applications:**

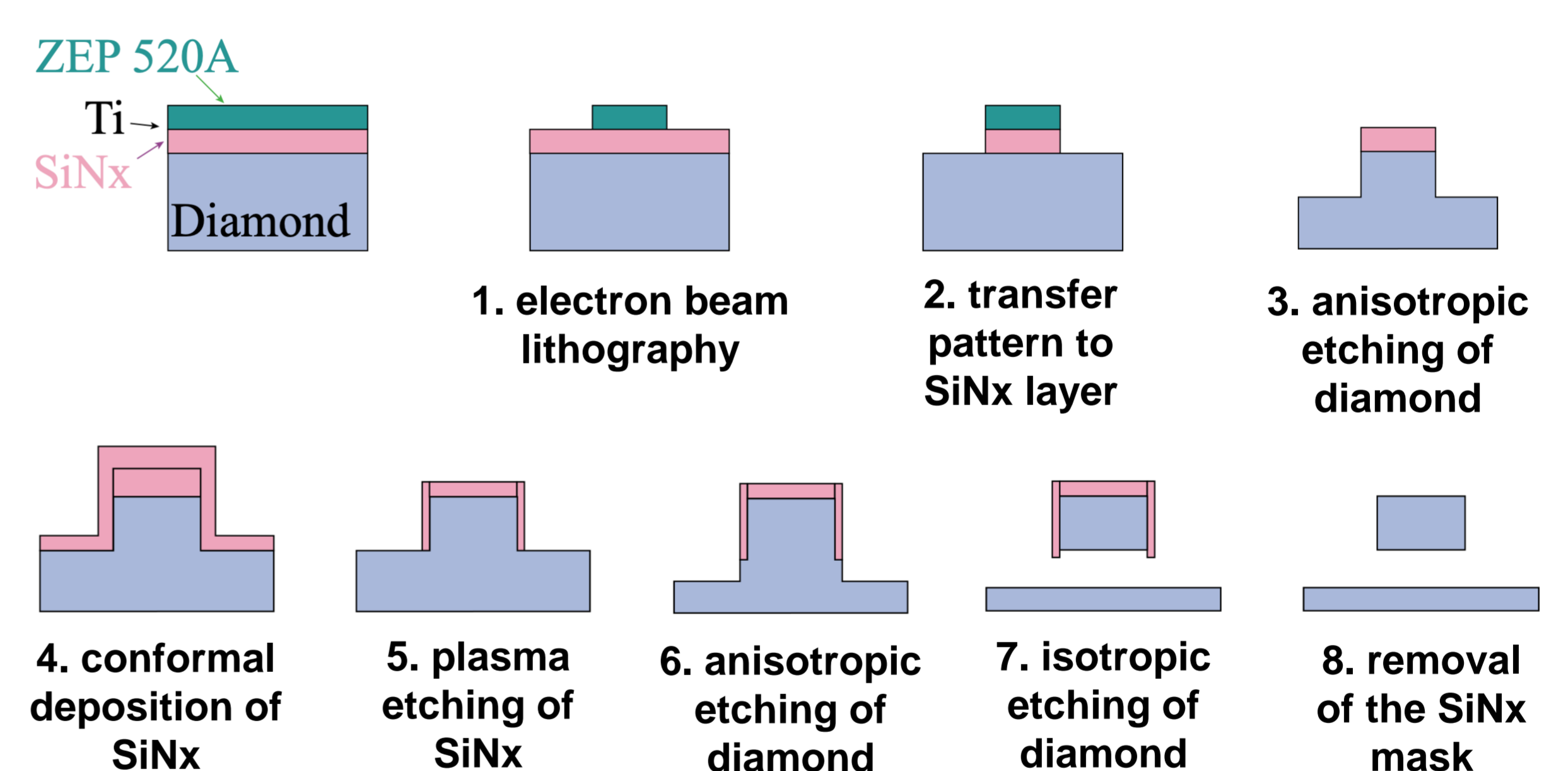
- Waveguide
- Resonators
- MEMS



Processed waveguides by Faraday cage angled-etching

Microring resonator generated by isotropic etching.

- Complete exposure of photonic nanostructures is necessary to guide light effectively
- Nanostructures in diamond are a challenge due to the mechanical and chemical resistance of the material
- Fully freestanding structures can be achieved by conformal coating and isotropic etching



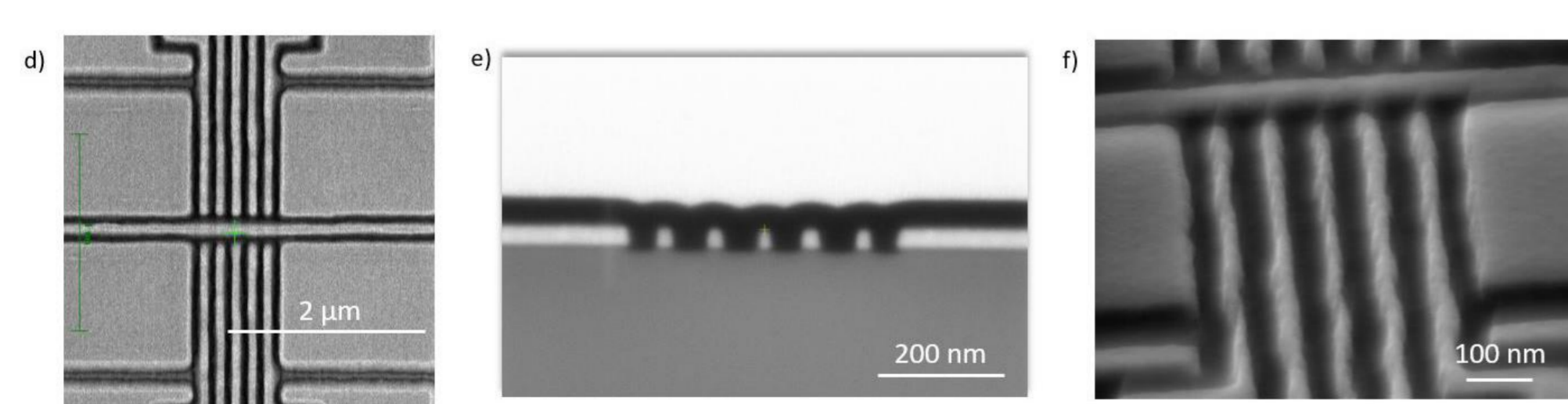
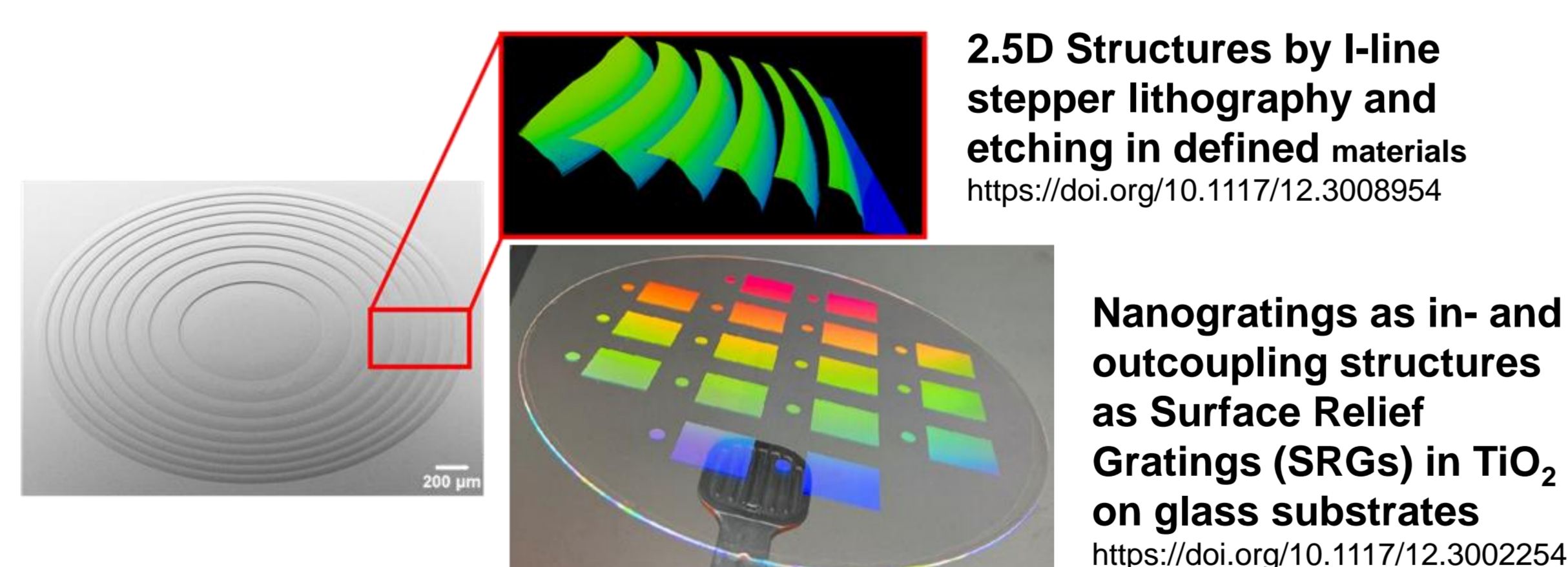
Pregolato, *et al*, APL Photonics 9, 036105 (2024)

## 3 Top-down nanopatterning at wafer level

- Nanopatterning consisting of lithography (e-beam + NIL) and etching of defined materials (e.g.  $\text{TiO}_2$ ) on up to 300mm wafer size available
- E-beam lithography with 80 nm pitch and variable line/space ratio demonstrated
- Lithography as 2.5D lithography opens up further possibilities

**Applications**

- Metastructures with unique properties such as negative refractive index for optics (VR, AR), sensor technology and telecommunications.
- High-resolution structures made of metal, superconductors,...



Gate nanostructures for electron spin qubits on  $\text{SiGe/Si/SiGe}$ , defined by e-beam lithography  
<https://doi.org/10.1117/12.2675943>

## 4 Summary

- Nanomaterials can be integrated on chips
- High-resolution lithography available at wafer level
- Waveguide structuring by quasi-isotropic etching and Faraday cage angled-etching established

