

Supporting information

Heavily Doped Germanium Pyramid Array for Tunable Optical Antireflection in Broadband Mid-Infrared Range

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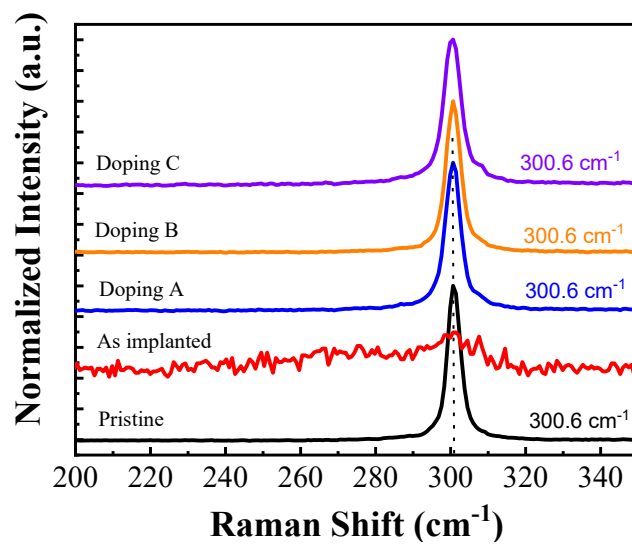


Figure S1. Raman spectra of pristine Ge and implanted Ge for Doping A, Doping B, and Doping C. The peak position is stated at the right side of peak positions.

Name	Ion	Acceleration Voltage (kV)	Ion Does (ions/cm ²)	Laser Fluence (mJ/cm ²)	Pulse No.	Doping Concentration (/cm ³)	Doping Depth (nm)
Doping A	P	25	1.0×10^{15}	825	1	4.0×10^{19}	100
Doping B	P	25	1.0×10^{15}	825	10	1.0×10^{19}	300
Doping C	P	25	4.0×10^{15}	825	10	4.0×10^{19}	300

Table S1. Ion implantation and laser annealing conditions for Doping A, Doping B, and Doping C. The activated doping concentration and depth after the laser annealing are shown.

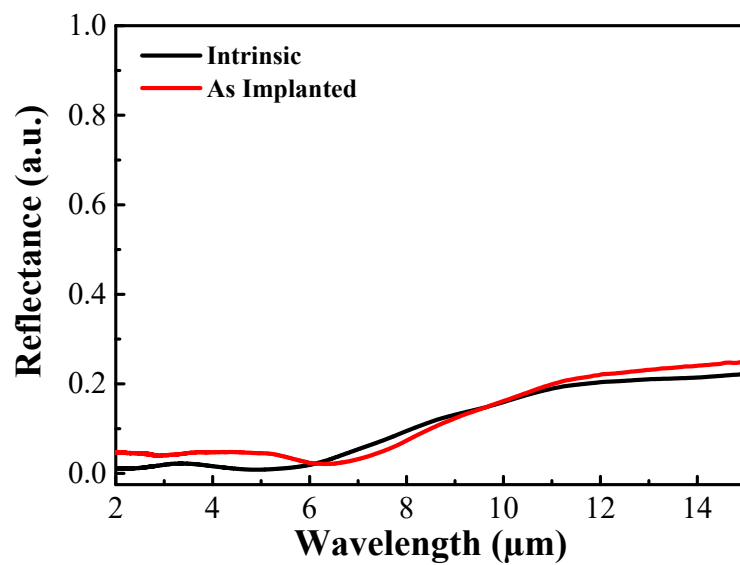


Figure S2. Reflectance spectra of as-implanted inverted Ge pyramid array and intrinsic inverted Ge pyramid array.

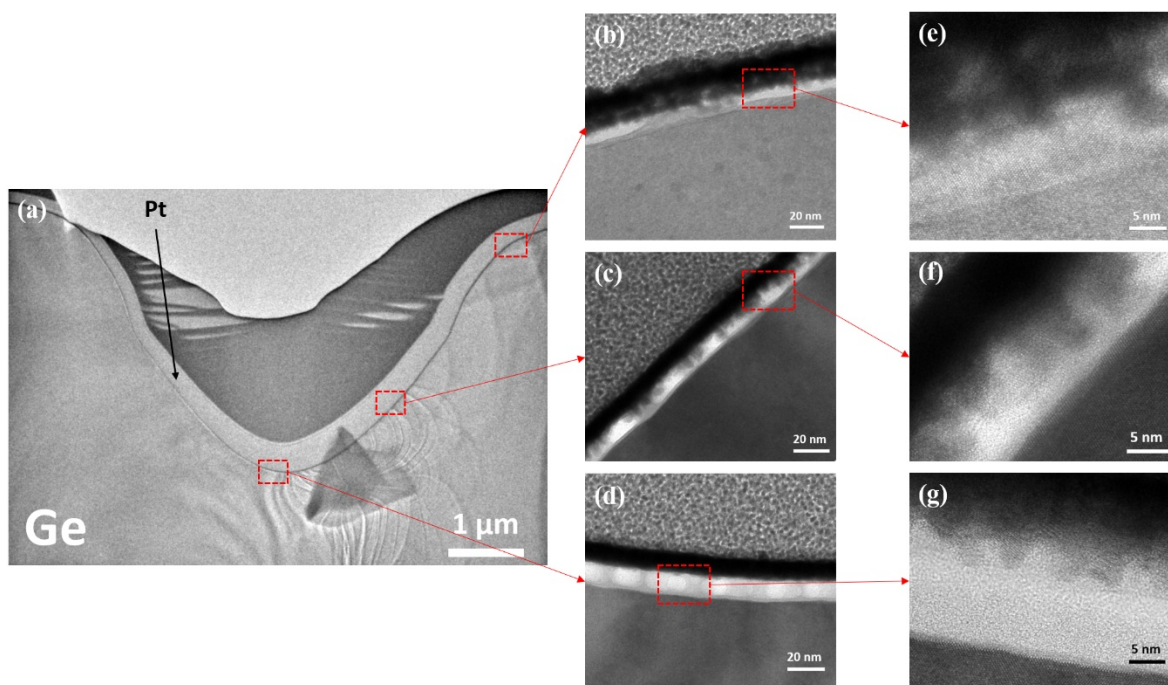


Figure S3. (a) A SEM image of the inverted pyramid. Zoom-in TEM images of the inverted pyramid at (b) edge, (c) sidewall, and (d) center. Enlargement with the image detail in the TEM image for the inverted pyramid at (e) edge, (f) sidewall, and (g) center.

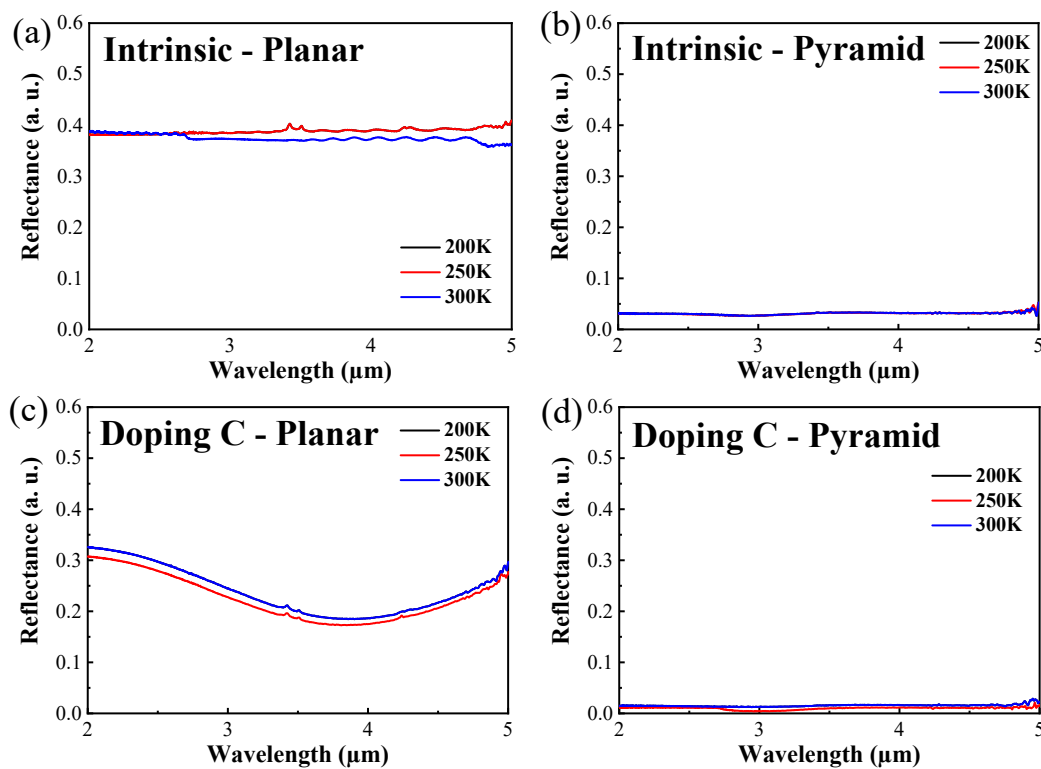


Figure S4. (a,b) Reflectance spectra of intrinsic planar and inverted pyramid array. (c,d) Reflectance spectra of doped planar and inverted pyramid array with Doping C at 200, 250, and 300 K.

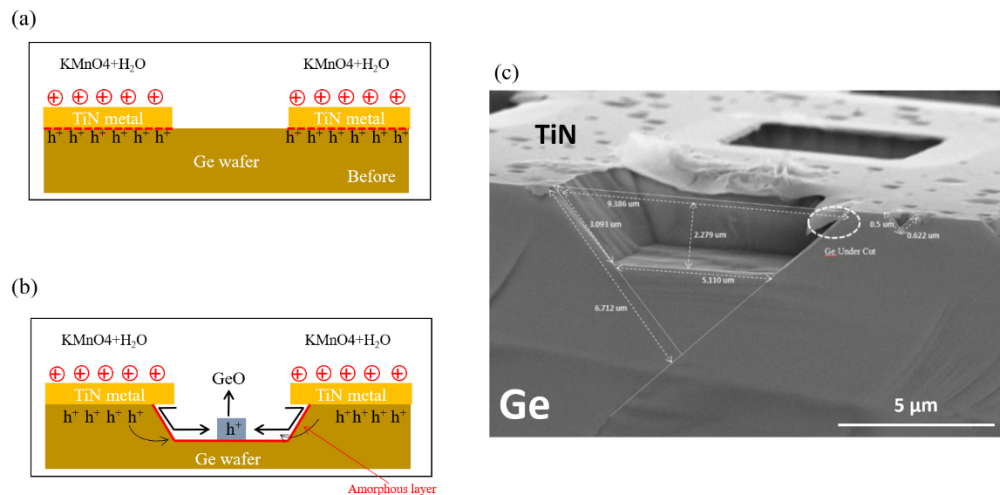


Figure S5. (a,b) Schematic mechanism of MacEtch process: An inverted Ge pyramid is etched by KMnO_4 and H_2O solutions on a Ge (100) substrate. Holes are generated from TiN/Ge interface and injected into the exposed Ge region. Accumulated holes oxidize the exposed Ge, followed by etching of the oxidized Ge. (c) SEM image of the MacEtched inverted pyramid. Undercut region is clearly observed at the edge of the inverted pyramid.