Epitaxial Growth of Low-Surface-Roughness Single-Crystal Germanium Thin Films by Unbalanced Magnetron Sputtering

Gui-Sheng Zeng,[1,#] and Sheng-Hui Chen [2,*]

[1]*National Center for Instrumentation Research, National Institutes of Applied Research, 20 R&D Rd. VI, Hsinchu Science Park, Hsinchu, Taiwan*

[2]*Department of Optics and Photonics, National Central University, 300 Chung-da Road, Chung-Li, Taoyuan, Taiwan*

Presenting author's e-mail: 2309241@narlabs.org.tw
*Corresponding author's e-mail: ericchen@dop.ncu.edu.tw

The development of silicon photonics has made breakthroughs in the heterogeneous epitaxy of components such as light sources, waveguides, and photodetectors on silicon substrates increasingly important [1]. In this study, an unbalanced magnetron sputtering gun was employed to extend the plasma region toward the substrate, facilitating the ionization of germanium atoms for epitaxial growth. nc-AFM surface morphology images of single-crystal germanium thin films are presented in Figures 1a–1d, corresponding to the optimized process parameters for (a) target-to-substrate distance, (b) sputtering power, (c) epitaxial temperature, and (d) valve opening. A notable increase in grain size is observed with the optimization of each individual parameter. Figure 1e summarizes the surface roughness of the samples. With the optimization of process parameters, the overall surface roughness (Rq) remains below 1 nm. The low-defect and smooth surface is beneficial for subsequent epitaxial processes. Figure 1f shows the XRD Omega scan, where the full width at half maximum (FWHM) rapidly decreases with the optimization of process parameters, indicating excellent single-crystal quality of the epitaxial germanium films. This study confirms the quality of the single-crystal germanium films using nc-AFM, providing a promising epitaxial process for future silicon photonics applications.

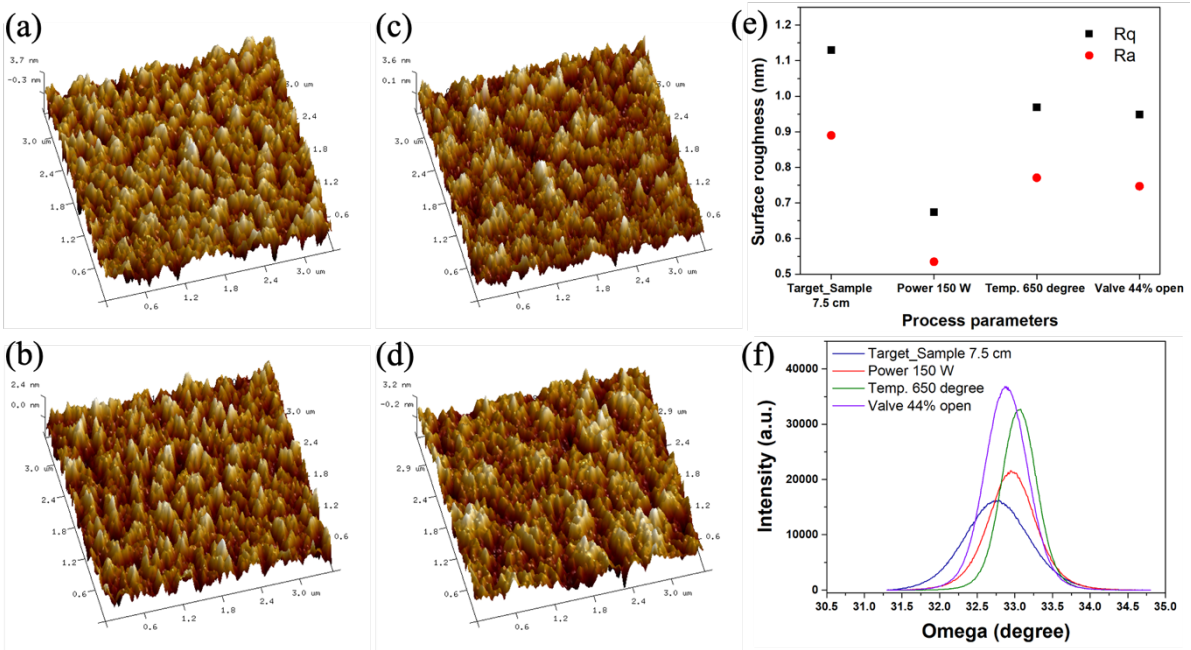

Figure 1. (a-d) nc-AFM surface measurement, (e) summary of surface roughness, (f) XRD crystallization measurement.

Reference

[1] D. Liu, P. Zhang, B. Tang, W. Wang and Z. Li, Micromachines, **13**, 649 (2022).