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Program and materials
16.30–16.50 TO-13
-Alontseva Darya, East Kazakhstan State Technical University, Kazakhstan. The structural phase changes in Ni-based coatings deposited by plasma detonation and the results of coatings modification by duplex treatment

16.50–17.10 Coffee break

Session V
Chairmen: A. Pogrebnyak, D. Milčius

17.10–17.40 TO-14 (Invited)
-Gintautas Abrasonis, Forschungszentrum Dresden-Rossendorf, Dresden, Germany. PVD growth of carbon-transition metal nanocomposites: from energetic condensation to spin-dependent transport

17.40–18.00 TO-15
-Liutauras Marcinauskas, Kaunas University of Technology, Lithuania, A. Grigonis. Formation of amorphous carbon structures at atmospheric pressure

18.00–18.20 TO-16
-Andrzej Misiuk, Institute of Electron Technology, Warsaw, Poland, C.A. Londos, W. Wierczowski, J. Bak-Misiuk, P. Romanowski, K. Wieteska, E.N. Sgourou, M. Prujszczyk. Oxygen-related defects in neutron irradiated n-containing Cz-Si annealed under enhanced pressure

18.20–19.30 P2 - Poster session, Chairman J. Pulišo

P2-1. A. Laurinavičius, A. Baltrušaitis, V. Pranckevičienė. Investigation physical properties of wood using millimeter wave radiation

P2-2. M. Gaspariūnas, A.V. Goncharov, V.V. Levenets, V. Kovalevskij, A. Plukis, R. Buzelis, S. Kyčas, V. Remeikis. RBS analysis of multilayered optical coatings


P2-4. J. Reklaitis, K. Mažeika, D. Baltrūnas, V. Remeikis. Rayleigh scattering of Mössbauer radiation in polystyrene

P2-5. J. Sapolaitytė, G. Lujanienė, E. Radžiūtė. Cs, Pu and Am interaction with the clay engineered barrier
OXYGEN-RELATED DEFECTS IN NEUTRON IRRADIATED N-CONTAINING Cz-Si ANNEALED UNDER ENHANCED PRESSURE

A. Misiuk¹, C.A. Londos², W. Wierczkowski³, J. Bak-Misiuk⁴, P. Romanowski⁴, K. Wieteska⁵, E.N. Sgourou², M. Prujszczyk¹

¹Institute of Electron Technology, Al. Lotnikow 46, 02-668 Warsaw, Poland, E-mail: misiuk@ite.waw.pl
²University of Athens, Panepistimiopolis, Zografos, 15784 Athens, Greece
³Institute of Electronic Materials Technology, 01-919 Warsaw, Poland
⁴Institute of Physics, PAS, Al. Lotnikow 32/46, 02-668 Warsaw, Poland
⁵Institute of Atomic Energy, 05-400 Otwock-Swierk, Poland

Abstract

Creation and transformation of oxygen-related defects in N-doped Czochralski silicon (Cz-Si:N), irradiated with 5 MeV neutrons, D=1x10¹⁷ cm⁻² (n-Cz-Si:N), and annealed at up to 1400 K (HT) under Ar hydrostatic pressure (HP) up to 1.1 GPa, are investigated. Processing of Cz-Si:N and n-Cz-Si:N at 1270 K and 1400 K, especially under HP, results in a formation of oxygen-related defects, e.g. processing at 1400 K under 1.1 GPa favours a creation of spheroidal SiO₂ₓ precipitates. Neutron irradiation and subsequent HT-HP processing enable to prepare Cz-Si:N with specific microstructure.

Key words: Cz-Si, nitrogen, neutron irradiation, annealing, hydrostatic pressure, oxygen-related defects.

Nitrogen admixture in oxygen-containing Czochralski grown silicon (Cz-Si) affects strongly its properties [1,2]. Processing of Cz-Si:N at 1000-1400 K (HT) under enhanced hydrostatic pressure (HP) results in enhanced oxygen precipitation with creation of numerous oxygen-related defects [3].

The effect of sequential treatment (HT ≤1400 K, HP exerted by Ar up to 1.1 GPa) on creation and transformation of oxygen-related defects in P-doped Cz-Si with interstitial oxygen content, cₐ=8.3x10¹⁷ cm⁻³, admixed with nitrogen to cₓ=2x10¹⁵ cm⁻³, and irradiated with 5 MeV neutrons at 1x10¹⁷ cm⁻³ dose, is now investigated by infrared (IR) and X-ray / synchrotron methods (topography at DESY HASYLAB Hamburg, X-ray reciprocal space mapping, XRRSM).

Pre-annealing of reference Cz-Si:N and of neutron-irradiated n-Cz-Si:N at 723 K produces so-called thermal donors (TDs); some of them can serve as the nucleation centres (NC’s) for subsequent precipitation of interstitial oxygen. The effect of such pre-annealing on the creation of defects after processing of pre-annealed samples at 1270 K under HP (such processing affects markedly oxygen precipitation, especially under HP [4]) is now confirmed by synchrotron topography (Fig. 1) and X-ray measurements (Fig. 2).
Fig. 1. Section topography of samples pre-annealed for 10 h at 723 K and subsequently processed for 5 h at 1270 K under 1.1 GPa: n-Cz-Si:N pre-annealed under 1.1 GPa (A), Cz-Si:N pre-annealed under 1.1 GPa (B), n-Cz-Si:N pre-annealed under $10^5$ Pa (C). Topography recorded at the F1 and S2 stations of the DORIS III synchrotron in HASYLAB (Germany).

Fig. 2. XRRSM’s of samples pre-annealed for 10 h at 723 K and subsequently processed for 5 h at 1270 K under 1.1 GPa: n-Cz-Si:N pre-annealed under 1.1 GPa (A), n-Cz-Si:N pre-annealed under $10^5$ Pa (B), Cz-Si:N pre-annealed under 1.1 GPa (C). Axes are given in reciprocal space lattice units (rlu).
Fig. 3. Deconvolution of IR spectra of pre-annealed samples after processing for 5 h at 1400 K under 1.1 GPa: A - n-Cz-Si:N pre-annealed for 10 h at 723 K under $10^5$ Pa + for 5 h at 1270 K under 1.1 GPa, B - n-Cz-Si:N pre-annealed for 10 h at 723 K under 1.1 GPa + for 5 h at 1270 K under 1.1 GPa + for 5 h at 1400 K under $10^5$ Pa, C - Cz-Si:N pre-annealed for 10 h at 723 K under $10^5$ Pa + for 5 h at 1270 K under 1.1 GPa.

The defect density was the highest for n-Cz-Si:N pre-annealed at 723 K under 1.1 GPa (so with the highest concentration of TDs – compare Fig. 1A), lower for Cz-Si:N pre-annealed also under 1.1 GPa (Fig. 1B), and the lowest for n-Cz-Si:N pre-annealed under $10^5$ Pa (Fig. 1C). This means that both NC’s created by pre-annealing at 723 K as well as the ones produced by neutron irradiation are contributing to the creation of defects at annealing.

Similar conclusions can be drawn from X-ray reciprocal space mapping (Fig. 2). While XRRSM’s are quite similar, the lower intensity of diffusively scattered X-rays (Fig. 2B) for the n-Cz-Si:N sample pre-annealed at 723 K under $10^5$ Pa, in comparison to that for the samples processed under HP (Figs 2A and C), suggests important role of TDs in the creation of oxygen-related defects (the concentration of TDs increases markedly with HP applied at processing at 723 K).
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Processing at even higher temperature results in complicated transformations of earlier created defects (Fig. 3).

While processing of Cz-Si:N and of n-Cz-Si:N for 5 h at 1270 K under 1.1 GPa results in the creation of numerous small defects, the treatment at 1400 K under HP, especially of n-Cz-Si:N, produces also the spheroidal SiO$_2$-x precipitates [5], more numerous than these in the similarly treated reference Cz-Si:N samples (the peak near 1210 cm$^{-1}$, compare Fig. 3A with 3B and C).

Neutron irradiation of Cz-Si:N introduces specific NCs of VO$_x$ type [6] for subsequent oxygen precipitation, as revealed especially after processing under HT-HP. This means that neutron irradiation and subsequent HT-HP treatment make it possible to prepare Cz-Si:N with specific microstructure. On the other hand, investigation of n-Cz-Si:N (Cz-Si:N is considered as relatively hard in respect of irradiation damages) after its subjecting to the HT-HP treatment can contribute to determination of its irradiation history and, possibly, can be applied for the post-irradiation dosimetry (compare [7]).

References