MeV Electron Irradiation In-Situ HVEM Studies on the Impact of Doping on {113}-Defect Formation in Silicon

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High fluxes of electrons with energies above 200 keV create self-interstitial clusters in thin Si foils [1] and are observed as {113}-defects with {113}-habit planes and elongated along <110>-directions (Figs. 1 and 2). Dopants influence the {113}-defect formation kinetics and stability which also depend strongly on irradiation temperature as illustrated in Figs. 3 and 4 [2].

In-situ irradiation in UHVEM was also used to study the impact of Ge and O doping on {113}-defect formation in Si (Figure 5) [3]. 2 MeV electron irradiations (~ $4x10^{20}$ e $cm^{-2}s^{-1}$) were performed at room temperature and at 300°C. High resistivity floating zone grown (HRFZ-) Si was compared with magnetic field assisted Czochralski grown Si (MCz-Si) containing $5.7x10^{17}$ O atoms/cm^3 and with Cz-Si doped with $6.5x10^{20}$ cm^{-3} Ge (GCz-Si).

Both in MCz- and GCz-Si, a retardation of {113}-defect formation is observed compared to HRFZ-Si probably related to the presence of additional sinks for interstitials. An important influence of specimen thickness is observed, whereby defect formation is retarded in thin and thick specimen areas (Figure 6). In thin areas, this is due to the dominance of the specimen surfaces acting as sinks for both interstitials and vacancies. Starting from a critical specimen thickness, the faster diffusion of vacancies to the specimen surface leads to an increasing interstitial concentration and to nucleation of <113>-defects. In even thicker areas, diffusion towards the bulk and recombination of vacancies and interstitials becomes more important as the distance to the surface becomes too large. This leads to a lower interstitial supersaturation and to a delay in <113>-defect nucleation and growth. The observations are discussed in the frame of the theory of quasi-chemical reactions.

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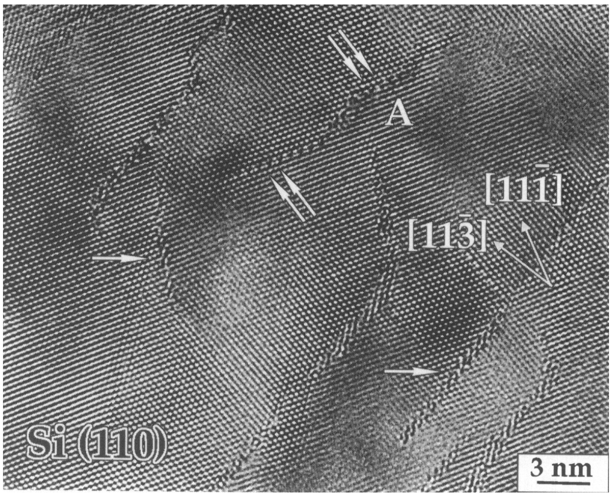
References

[1] A. L. Aseev, L.I. Fedina, D. Hoehl and H. Bartsch, “Clusters of Interstitial Atoms in Silicon and Germanium”, Akademie Verlag GmbH, Berlin (1994).

[2] J. Vanhellemont, A. Romano-Rodriguez, L. Fedina, J. Van Landuyt and A. Aseev, Mat. Science and Techn. 11 (1995) 1194.
[3] J. Vanhellemont, H. Yasuda, Y. Tokumoto, Y. Ohno, M. Suezawa and I. Yonenaga, Phys. Status Solidi A 209 (2012) 1902.



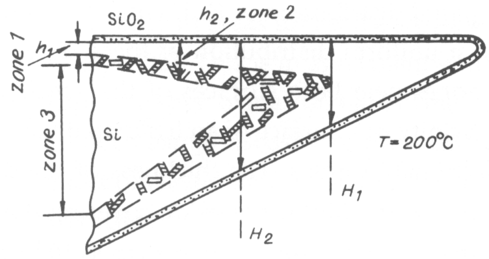


Figure 1 **Left:** {113}-defects created during 400 keV irradiation (10^{20} e $cm^{-2}s^{-1}$). **Right:** Schematic of {113}-defect formation in a wedge shaped specimen [1].

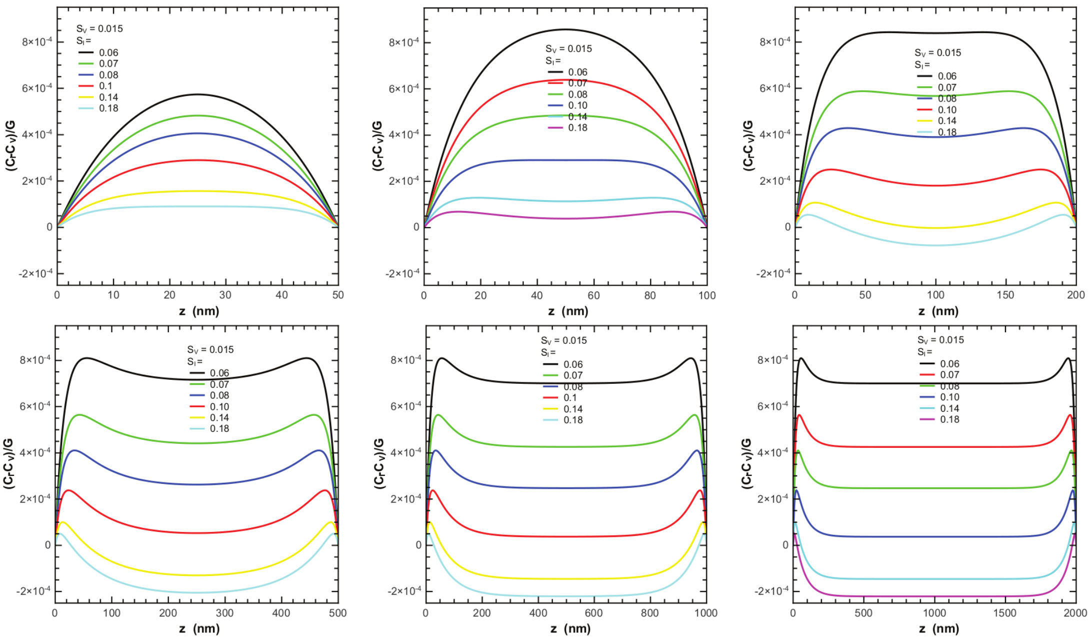


Figure 2 Calculated ratio of generated interstitials over electron flux during 2 MeV electron irradiation as a function of specimen thickness and surface sink strength for intrinsic point defects for different irradiation temperatures [3].

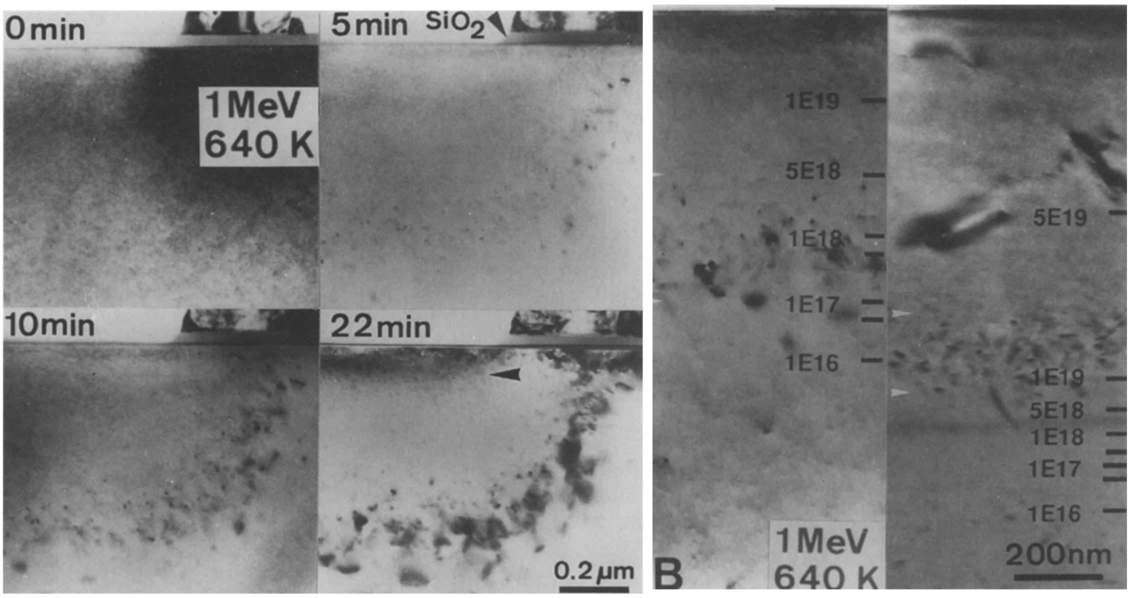


Figure 3 **Left:** Evolution of B implanted and annealed sample during 1 MeV electron irradiation ($2x10^{19}$ $cm^{-2}s^{-1}$). **Right:** {113}-defect distribution for two different boron concentration profiles after 15 min irradiation [2].

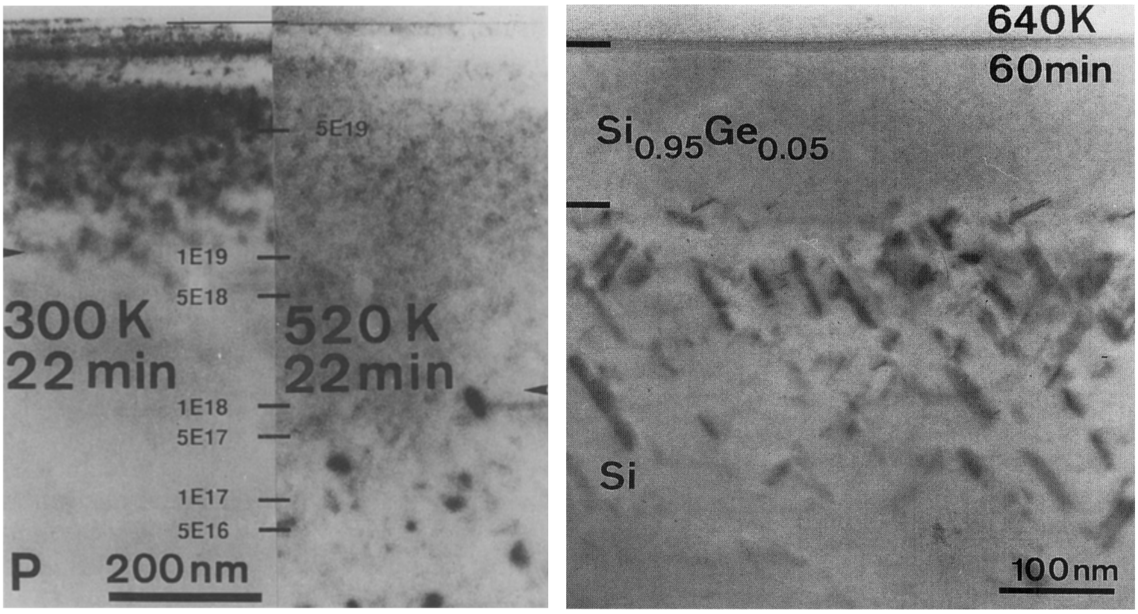


Figure 4 **Left:** P implanted and annealed sample irradiated (1 MeV, $2x10^{19}cm^{-2}s^{-1}$) at temperature below (left) and above (right) the stability temperature of the V-P pair. At 300K, defects are dominantly formed in areas with P concentration above 10^{19} cm^{-3}. At 520 K, they are formed mainly for concentrations < $5x10^{17}$ cm^{-3}. **Right:** Strained $Si_{0.95}Ge_{0.05}$ layer structure after 1 MeV irradiation for 60 min with $2x10^{19}$ e $cm^{-2}s^{-1}$. No defects are observed inside the Si-Ge layer [2].

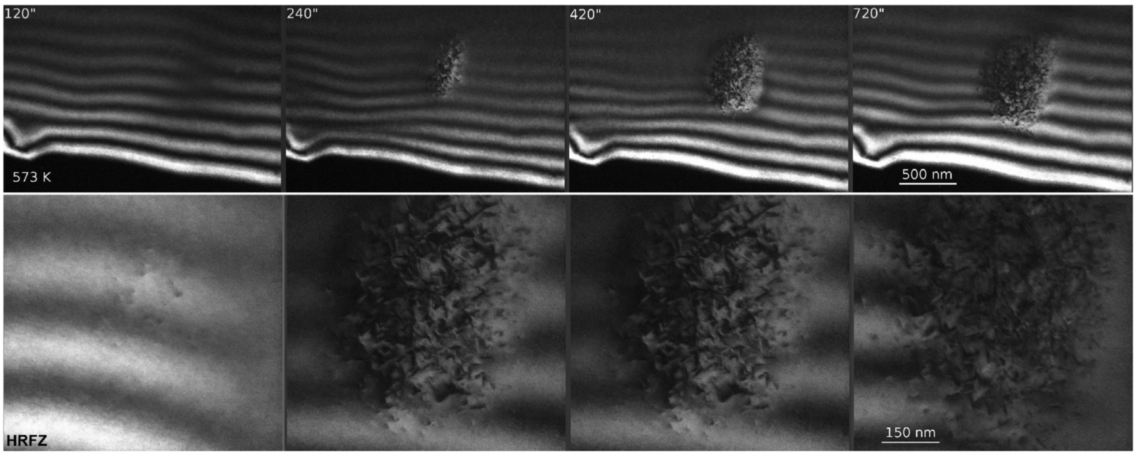


Figure 5 Dark field images illustrating defect formation during 2 MeV e-irradiation (3.2x10^{20} e cm^{-2}s^{-1}) of HRFZ. **Top figures:** The hole in the thinned specimen is the black area at the bottom. **Bottom figures:** Higher magnification of the same defect area [3].

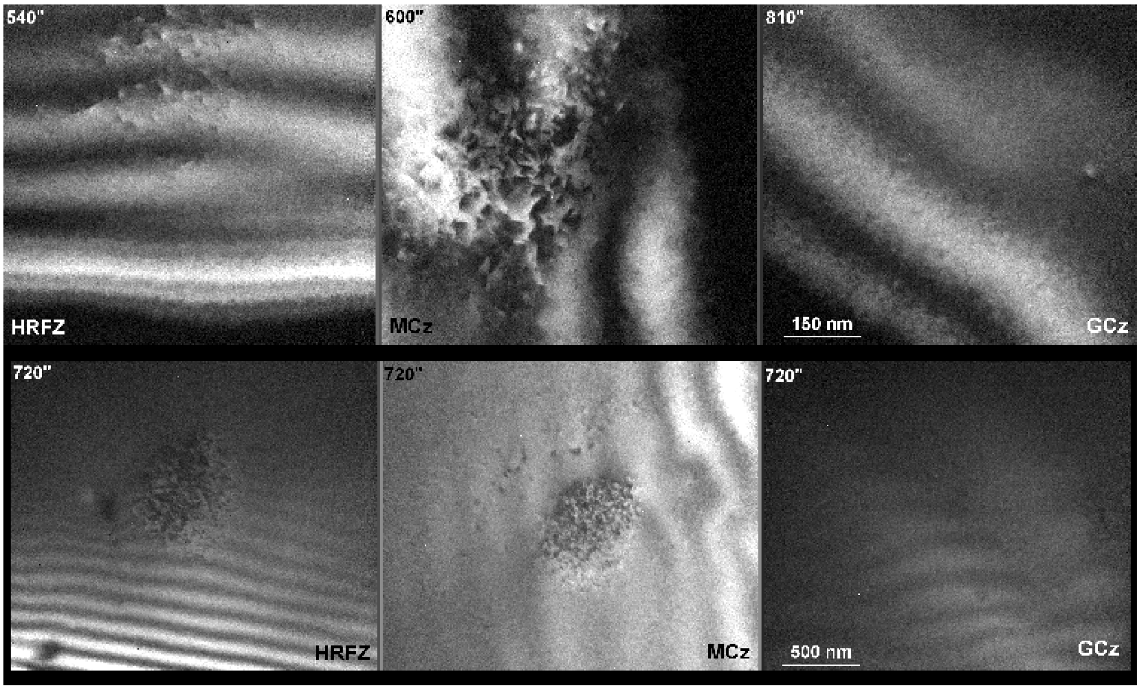


Figure 6 Dark field images showing defect formation during 2 MeV irradiation at 573 K. The top figures show thin areas (<250 nm) of HRFZ (hole at the bottom), MCz (hole to the right) and GCz (hole at the bottom left) specimens. The bottom figures are for thick areas (~1300 nm) [3].

大阪大学超高圧電子顕微鏡センター

材料系共同利用研究報告会

超高圧電子顕微鏡による学術研究は、我国がこれまで世界的にリードし、今後も最先端を走り続ける分野と考えられています。この度、大阪大学超高圧電子顕微鏡センターを利用して得られた研究成果の報告会を開催いたしますので、ふるってご参加ください。

日時：平成24年12月20日（木） 13:00-19:00
場所：大阪大学産学連携本部A棟1階セミナー室
（旧先端科学イノベーションセンター・インキュベーション棟A棟1階セミナー室）

プログラム

13:00-13:10 開会の挨拶 保田 英洋（大阪大学）

座長:保田 英洋（大阪大学）

13:10-13:50 MeV Electron Irradiation In-Situ HVEM Studies on the Impact of Doping on {113}-Defect Formation in Silicon
Jan Vanhellemont（Ghent University）

13:50-14:20 面内に複屈折を有する(110)ポーラスシリコンの3次元構造解析
藤井 稔（神戸大学）

14:20-14:50 超高圧電子顕微鏡による金属における自己格子間原子のダイナミクスの抽出
荒河 一渡（島根大学）

14:50-15:00 休憩

座長:永瀬 丈嗣（大阪大学）

15:00-15:30 いくつかの形状記憶合金に現れる散漫な衛星反射
福田 隆（大阪大学）

15:30-16:00 電子照射によるアモルファス酸化物の結晶化
～その場観察による構造変化の追跡～
仲村 龍介（大阪府立大学）

16:00-16:10 休憩

座長:小林 慶太（大阪大学）

16:10-16:40 III-V族化合物半導体GaSb, InSbの電子照射による構造変化
新田 紀子（高知工科大学）

16:40-17:10 MeV電子照射による純金属ナノ粒子の構造不規則化と相転移
保田 英洋（大阪大学）

17:30-19:00 懇親会 於 さわらび（参加費:3,000円）

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