どこまで Ge-CMOS 技術は進んでいるのか - イントロダクション -

- Introduction - Be positive about germanium!

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Germanium is the material which was intensively investigated more than 50 years ago, and was replaced by Si. Although we learned Ge was roughly the same as Si in the undergraduate course, what is different between Ge and Si? Since Ge CMOS is considered as a post-Si CMOS, the FET performance should be above Si one. Since there are no other competitors in p-channel materials against Ge, many technical issues belong to n-channel FETs in terms of CMOS applications. Gate stack and source/drain technology fundamentals are main issues to investigate. Furthermore, both scalability and reliability of Ge CMOS are unfortunately the MUST requirements from the early stage in R&D.

In this symposium, EOT, carrier mobility and contact resistance will be mainly discussed as fundamental properties for high performance MOSFETs. In the introduction, I would focus on Ge substrate effect on FET properties from a little different viewpoint. Two kinds of Ge wafers (A & B) were employed for FET fabrication. FET (A) on the wafer-A shows the record-high electron mobility, while FET (B) on the wafer-B shows much lower electron mobility, though exactly the same fabrication process was employed. The reason is not exactly clear, but phenomenologically the oxygen concentration in Ge is different between two wafers. An interesting point is that the oxygen concentration in Wafer-B is really reduced in H_2 annealing at relatively high temperature and then electron mobility is significantly improved, as shown in **Fig. 1.** D_{it} is not changed at all, as shown in **Fig. 2**. This is quite interesting.

ref. *C. H. Lee et al., iedm 2013, 2014.*

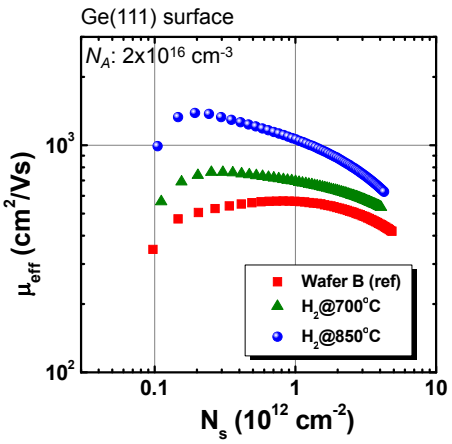

Fig. 1 Electron μ_{eff}-Ns relationship in MOSFETs prepared on Ge wafer-B annealed in H_2 at two different temperatures. The reference without H_2 annealing is also shown.

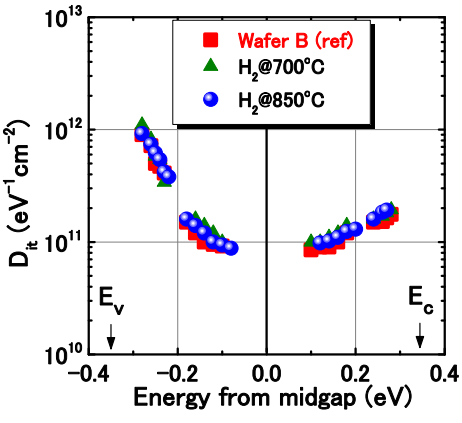

Fig. 2 Interface states density (D_{it}) in MOS capacitors prepared on Ge wafer-B annealed in H_2 at two different temperatures. The reference without H_2 annealing is also shown.