Ge-compatible resist stripping processes

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Abstract: Highly oxidizing resist ashing processes are known to cause Ge loss because of water solubility of GeO_2. To limit this drawback, the addition of Nitrogen in the plasma to create a passivation layer during the ash process was studied. Thanks to this surface layer, a good compatibility level can be found for a post etch ash process

Introduction

Due to its better carrier transport properties compared to Si and the introduction of High-K material in the gate structure, Ge is in the highlights again.

Because of its non-compatibility with current stripping processes, due to the water solubility of the GeO_2 [1], dedicated resist removal processes have to be found.

The aim of this study is to find an efficient resist stripping process for Ge based substrates. To achieve this, the creation of a passivation layer during the dry step to protect Ge from the oxidizing step was investigated. As N_2 or H_2 additions in plasma are known to passivate sidewalls in anisotropic etching [2], addition of these gases to a standard ash process was studied.

Experimental

Experiments were performed on Poly-Ge-On-Insulator (Poly-GeOI) wafers. The CVD poly Ge was deposited on oxidized 200mm Si wafers.

Dry processes were carried out on different single-wafer process tools, featuring downstream type plasmas. Available gases were N_2-H_2 forming gas, O_2, and CF_4. Wet cleanings were performed on wet benches.

Compatibility measurements were performed on an ellipsometer and CD-loss measurements on a Scanning Electron Microscope for Critical Dimension (SEM-CD).

Results and discussion

An initial compatibility study was done on Poly-GeOI wafers. The $(GeON)_x$ passivation layer growth (in grey) and Ge loss (in black) are represented, on Fig.1. These measurements show that the more important the $N_2/(O_2+N_2)$ ratio, the thinner the passivation layer. A point to underline is for the $N_2/(O_2+N_2)$ ratio at 0.57: a saturation in the $(GeON)_x$ growth can be seen, leading to the lowest Ge consumption. The $(GeON)_x$ growth is stable, which indicates the passivation is ended.

Two different $N_2/(O_2+N_2)$ ratio plasma were then tested after active area etching: one at 0.1, which corresponds to the standard ash plasma used, and a more compatible one at 0.45. Results of the CD loss measured for each ratio and after HF dip are shown Fig.2. Increasing the N2 ratio improves sidewall protection, and then reduces the CD loss. For both plasma treatments, the total loss is lower than the one induced by a single wet treatment, which proves the effectiveness of the Ge nitride passivation.

To evaluate the effectiveness of the stripping processes, SEM cross sections are shown on Fig.3. The resist removal is not complete after dry step process as residues can be seen (Fig. 3-a and 3-b). Those are completely removed by an HF 1% dip (Fig.3-c and 3-d).

Conclusions

For the Ge active area stripping, an acceptable compatibility level has been found for the ash step. Studies must continue to minimize CD loss during a water rinse. XPS analysis will allow to better understand the passivation mechanisms and also the passivation layer behaviour during a water rinse.

References

[1] K. Prabhakaran et al, *Surf. Sc.*, 325 (1995) 263-271.

[2] C. Monget et al, *J.Vac.Sci. Technol B*, 1833 (1998).

Figures

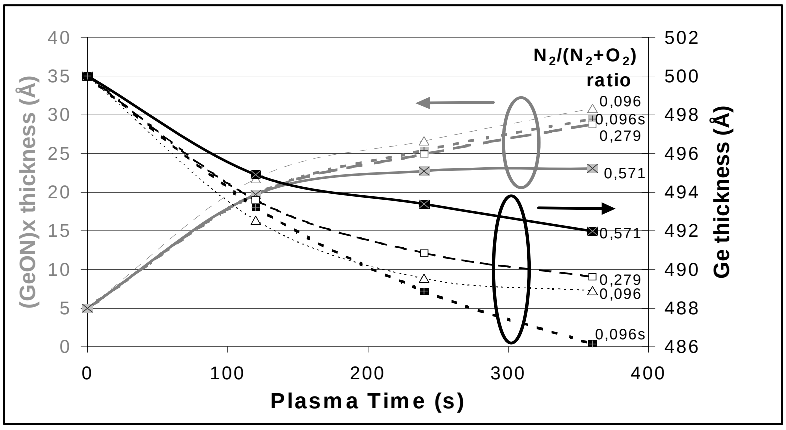

Figure 1: (GeON)x growth and Ge etch for different N/(N+O) ratio plasma

Process	After Dry process	After HF 1% 30s
$N_2/(N_2+O_2)$ ratio= 0.1	4	20
$N_2/(N_2+O_2)$ ratio = 0.45	3	14
HF1%+ 15 min rinse	x	24
HF 1% + 10 min rinse	x	19

Figure 2: Average of CD loss (nm) ± 1.5 nm, after stripping on Ge

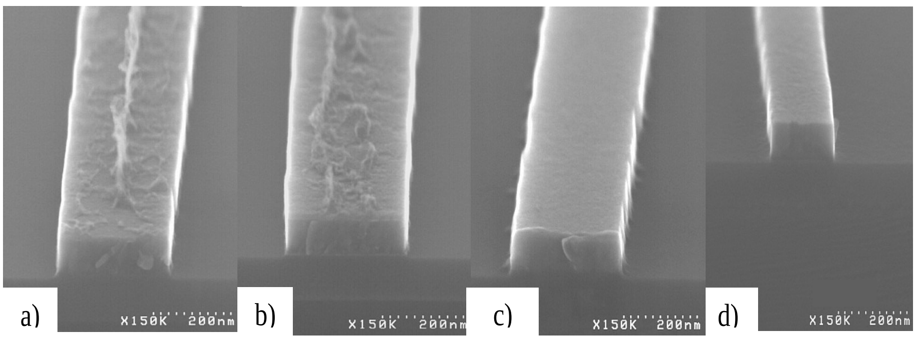

Figure 3: SEM cross section after stripping on PolyGe : a) $r=N_2/(N_2+O_2)=0.1$ ratio dry process b) r=0.45 dry process c) r=0.1 dry process + HF 1% dip d) r=0.45 dry process + HF1% dip.