UV absorption spectroscopy to study the role of CF radicals during cryogenic etching of Si in CF_4 plasmas

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Ultraviolet absorption spectroscopy is used to monitor the CF and CF_2 radical densities in CF_4 inductively coupled Si etching plasmas (ICP) as a function of the substrate temperature [1]. Typical spectra are shown in Fig.1. It can be seen from the absorption spectrum of the CF radical in Fig.1(a) that its density decreases dramatically when the wafer temperature is reduced from 20 to -130 °C under identical plasma conditions, demonstrating that the CF surface sticking coefficient increases as the surface temperature is reduced, while the CF_2 density remains nearly unchanged as it can be deduced from the corresponding absorption spectrum. This suggests that a CF_4 plasma could be used to form sidewall passivation layers and perform anisotropic etching at cryogenic temperature, which is impossible at room temperature.

Subsequently, a cyclical Bosch type etching process of silicon was evaluated at -100 °C using CF_4 plasma to passivate the trench sidewalls. Anisotropic etch profiles were obtained with an etch rate of 4.4 µm/min. Compared to a typical Bosch process using highly polymerizing c-C_4F_8 plasma, chamber wall contamination could be significantly reduced, alleviating a major issue of this cyclic process. Furthermore, CF_4 has a 28% lower global warming potential than c-C_4F_8.

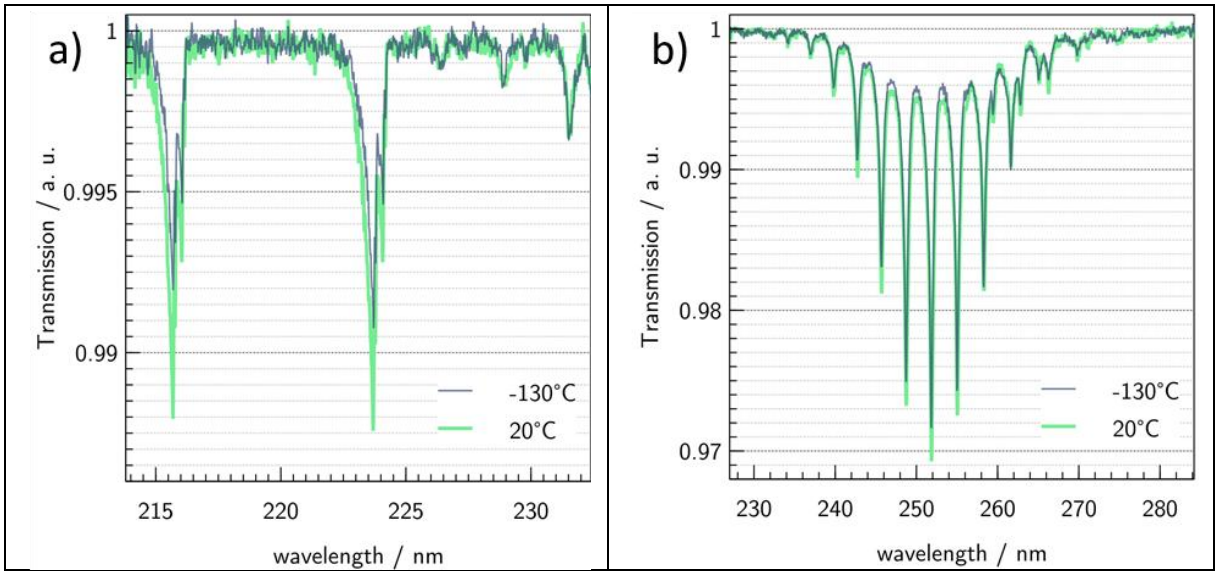

Figure 1 : *Absorption spectra measured in a CF_4 plasma (50 sccm, 4 Pa, 1.5 kW ICP power, no bias power) for chuck temperatures of 20 °C and -130 °C. (a) A $^2\Sigma \leftarrow X\ ^2\Pi$ (1,0) transition of CF and (b) A(0, v, 0) $\leftarrow$ X(0, 0, 0) transition of CF_2.*

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Références

[1] J. Nos, S. Iséni, M. Kogelschatz, G. Cunge, P. Lefaucheux, R. Dussart, T. Tillocher, E. Despiau-Pujo, APL **126**, 031602 (2025)

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