Defect generation and damage functions in electron irradiated silicon – dependence on the particle energy

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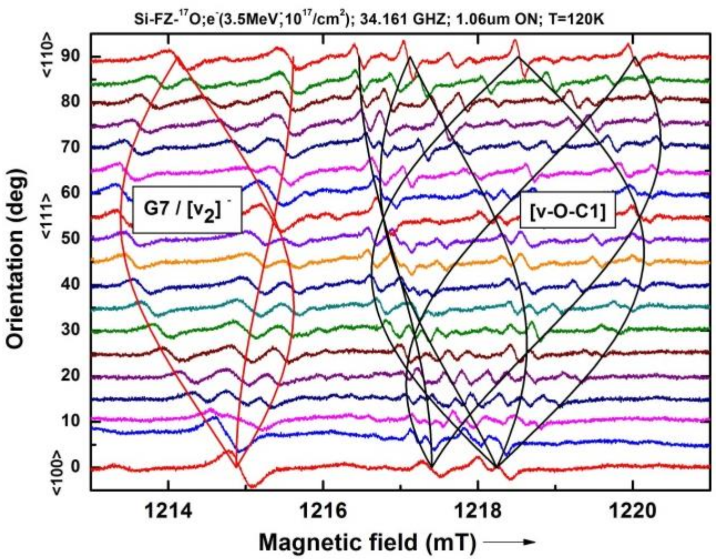
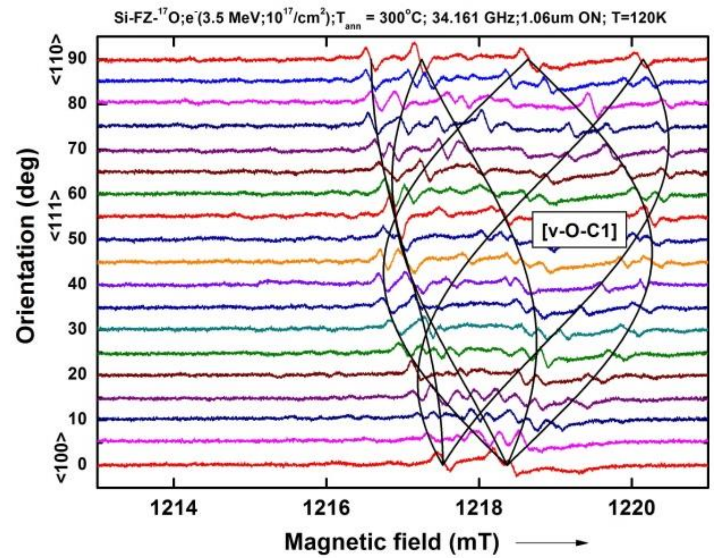
EPR investigations (All spectra (paramagnetic centers) reported so far could be observed only by in-situ illumination with 1.06 um light at T < 150K)**:**

- after irradiation with 3.5 MeV electrons ($\Phi=10^{17}$ cm^{-2})



• **Si-FZ-17O** as irradiated

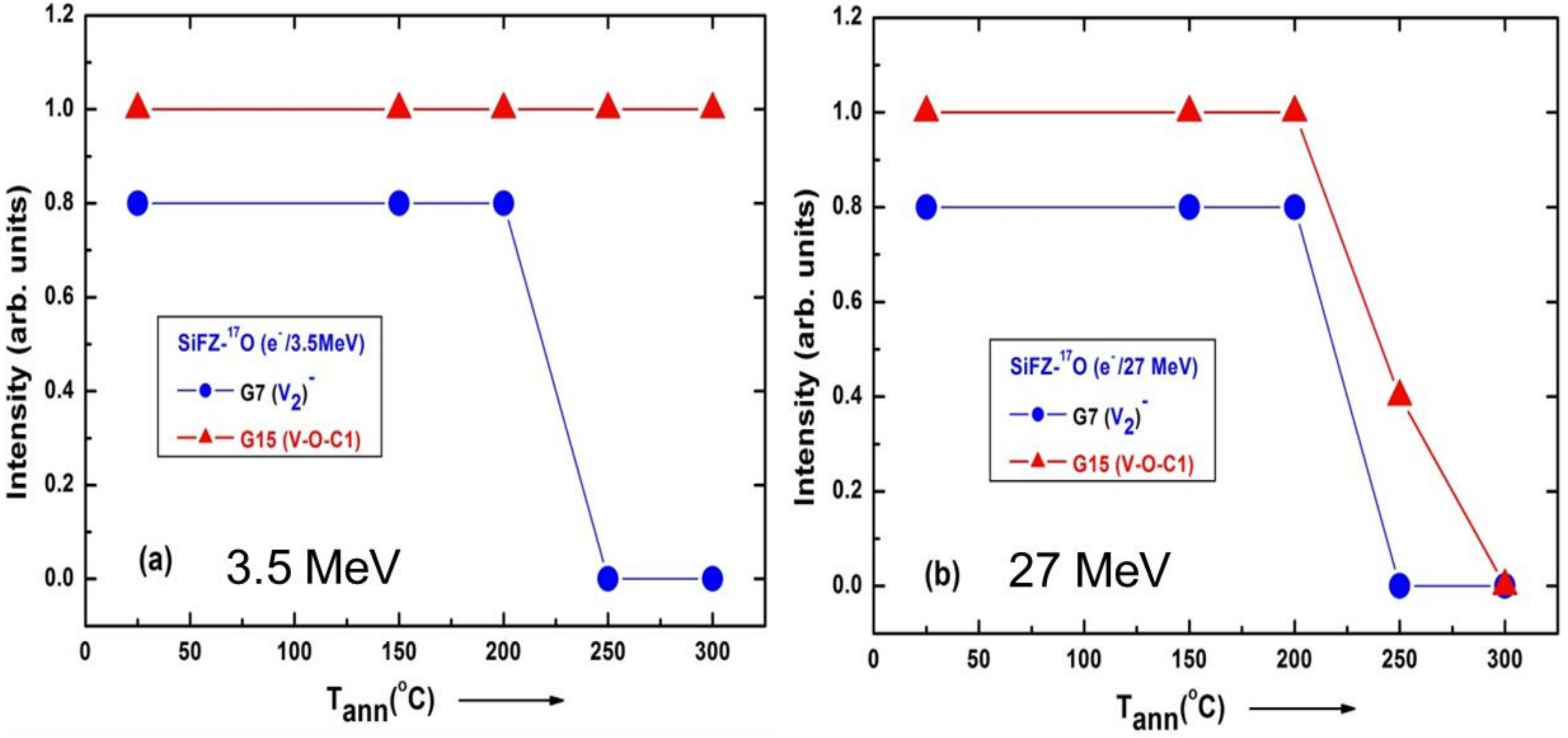


b) **Si-FZ-17O** after annealing at 300^{0}C

Defect	Sample	g	T_{mas} (K)	Detection conditions	Annealing-out	Symmetry
G7 / $[(v_{Si})_2]^-$	Si-FZ-17O Si-FZ-ref	$g_{\|\|} = 2.0115$ $g_{\perp} = 2.0080$	120	- Irad. e^- + illum. 1,06µm	$T_{ann} > 200$ C $T_{ann} > 200$ C	Trigonal <111>
G15 / $[v_{Si}$ - O-C1]	Si-FZ-17O Si-FZ-ref (at the detection limit)	$g_1 = 2.0064$ $g_2 = 2.0054$ $g_3 = 2.0000$	120	Irad. e^- + illum 1,06µm	$T_{ann} > 300$ C $T_{ann} > 200$ C	monoclinic I

According to the position of C atom the VOC defect gives two signatures, VOC1 and VOC2, so far only the VOC1 was surely identified in our EPR studies.

Thermal stability after irradiation with 3.5 MeV or 27 MeV electrons



The VOC1 center is less thermal stable in samples irradiated with electrons of larger energy – indicates that the changes in the clusters structure, (e.g. the release of vacancies and interstitials) generates additional defect reactions (not significant after irradiation with 3.5 MeV electrons) destroying the VOC1 defect.

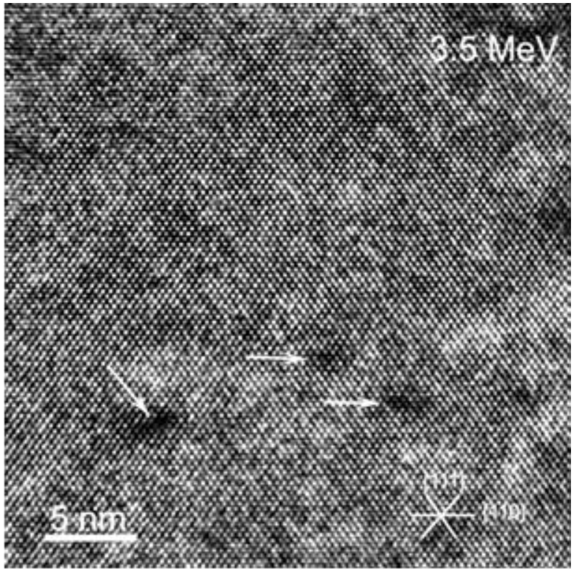
EPR work under way

- We are now investigating SiFZ100 (as grown) samples irradiated with 3.5 MeV electrons (fluence E 17/cm2) . In this sample the G7 (V2)- centers are present and the G15 (V-O-C1) centers are very much suppressed compared with its signal in SiFZ-O^{17}. There are also additional anisotropic weaker lines that makes the identification of the VOC1 unsure. To identify their angular dependence in better conditions we have to record again the whole set of set of spectra with increasead number of scans. This is a time consuming operation requiring ~ 2 weeks of 10 hours /day measurements for each angular dependence.
- Further info is expected from measurements at T < 40 K and from investigating the pulse annealed sample, which are underway. At the moment the first annealing step at + 150 C did not change the spectra observed at 120K.

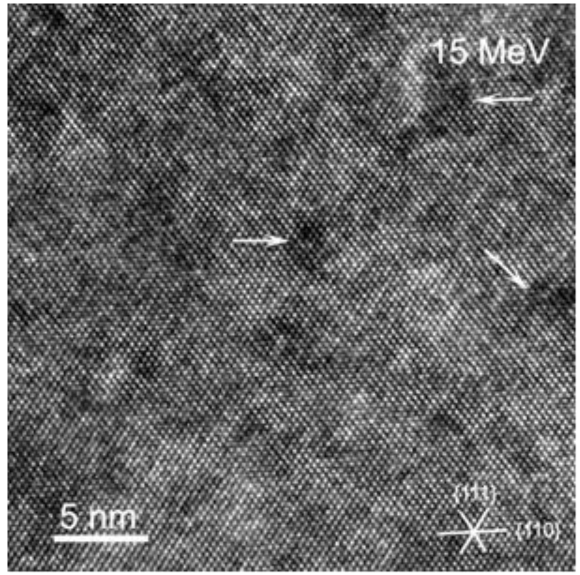
- Another set of EPR measurements will be done on a Si(DOFZ) sample also irradiated with 3.5 MeV electrons (fluence E 17/cm2).

Comparative HRTEM studies on FZ-Si samples irradiated with low and high energy electrons.

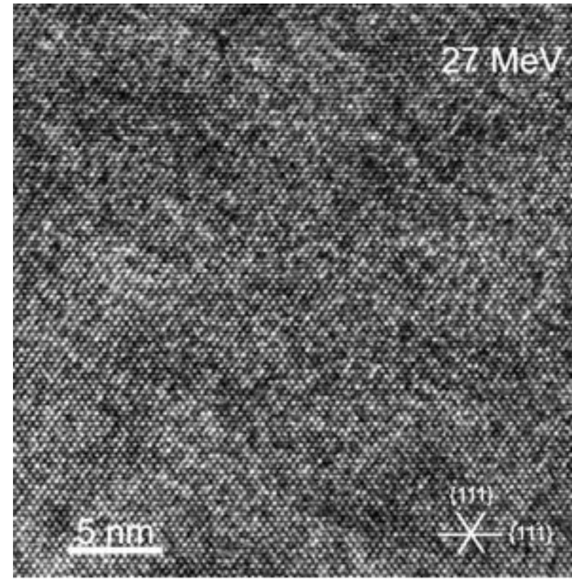
HRTEM image along the [110] zone axis on the sample irradiated with:



a) 3.5 MeV, $\Phi=10^{17}$ cm^{-2}



b) 15 MeV, $\Phi=1\times10^{16}$ cm^{-2}



c) 27 MeV, $\Phi=2\times10^{16}$ cm^{-2}

From the TEM/HRTEM studies on the three FZ Si samples irradiated with electrons in different conditions one can conclude the followings:

1. Irradiation with low energy (3.5 MeV) electrons and high fluencies (1×10^{17} cm^{-2}) produces extended defects as clusters of point defects.
2. The irradiation effects of low energy electrons and high fluencies are alike to those produced by electrons accelerated at relatively high energies (15 MeV) and a fluence one order of magnitude smaller.
3. High energy irradiations (27 MeV) and medium fluencies (2×10^{16} cm^{-2}) produce a very high density of agglomerates of point defect clusters.

HRTEM work under way

- annealing up to temperatures ~300 ^{0}C