2.2 Agglomerates of Point Defects in Silicon

2.2.1 Low Temperature Electron Irradiation Damage in Silicon

What it's About

- This topic was given to me for my PhD thesis work. My institute owned one of the very few "High Voltage Electron Microscopes" (HVTEM) that were in existence world wide (a 650 keV instrument from Hitachi). Moreover, it was equipped with a self-made specimen stage that allowed to cool the specimen to a very low temperature of 10 K (and anything above that to room temperature). That made it rather unique.
  - An electron energy of 650 keV is large enough to displace Si atoms every now and then, creating vacancies and self-interstitials. The resolution of the HVTEM then was not very good and you sure couldn't see point defects or very small agglomerates. At a temperature of 20 K or so the point defects were supposed to be immobile anyway, so you didn't expect to see much at all. However, heating up the specimen slowly after some irradiation time would render then mobile eventually, and you might see some agglomeration.
  - If things would have proceeded that way, we might have learned a lot about vacancies and interstitials in Si, and that would have been a good thing because not much was known about these little buggers that are at the heart of Si technology since they control diffusion, the key process for making p-n-junctions and thus transistors.
- It was not to be. Things turned out to be extremely complicated and whatever I could eventually see in my microscope was an "artifact", up top a point. The visible things (probably some interstitial agglomerates) were always close to the top surface of the specimen (the surface where the electron beam enters the Si) and obviously depended on some "dirt" to be "shot into" the Si to act as nucleation center for whatever nucleated.
  - Today, almost 50 years later, we still don't know all that much about intrinsic point defects in Si. However, I could make some interesting contribution in the second part of my thesis. This came about because Siemens company, then growing Si crystals, needed a HVTEM to look into the "swirl defect" enigma, and I was the guy named to help them with that. As it turned out, this business should become the major topic of my thesis, see the chapters 1 - 4.

Publication

- As far as publications goes, we have my thesis and one minor publications. Here are the links
  - **Thesis:**
    Chapter 5
    Chapter 6-7
  - **Publication:**

2 **FÖLL, H.:** High-voltage electron microscope studies of low-temperature radiation damage in silicon.
Inst. of Physics Conf. Series No. 23 (1975) p. 319
I wrote this publication long before I finished this work and discovered that I was looking essentially at surface related effects. Since the total results were not particularlyx enlightening, I did not write another publications covering all of this work. After all - there is my thesis!

Pictures

- I only give you the pictures in the thesis (more or less the same as in the publication) and a few extra ones.
  Here is the link

Pictures
Low Temperature Electron Irradiation Damage in Silicon

  - No large size pictures. They are just not that interesting!
- In case you wonder why I didn't look at the defects after productions in rthe HVTEM in a normal "high resolution" TEM (like the 125 keV Siemens TEM the MPI owned), there is a reason: The specimen were solidly glued into the special holder for low-temperature experiments and there was no way of getting them out without destroying them. There were too thick for normal TEM, anyway.