**Dislocations and vacancy clusters in silicon deformed at different temperatures**

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**Experiment**

- Plane-parallel silicon, P-doped (samples 1, 2, 3)
- Samples 1 and 2 were dynamically deformed in single-slip orientation under compression of at least 3 GPa and constant pressure in an argon atmosphere at room temperature and 130 °C. The deformation rate was 1.5 × 10^{-3} °C.
- Sample 3 was deformed with a constant strain rate of 2.2 × 10^{-6} °C/s under low applied stress from 0 to 20 MPa at 130 °C.
- Sample 3 was strained up to 16 %, sample 2 up to 9 %, sample 1 up to 3 %.
- Conventional fine-facet positron lifetime (FWHM ≤ 260 ps)
- Isochronal annealing up to 1300 °C in vacuum.

**Microstructure after RT deformation**

- High number of small cracks are formed in the early stages of the deformation-processing. Their existence is stopped when the pressure increases.
- The cracks provide sources for dislocation nucleation and dislocations are emitted from the free surfaces of cracks.
- Dislocations are diversified. The plastic deformation at high stress is controlled by perfect dislocation-dislocation interactions.

**Sample 3 deformed at 800 °C**

- Trapping rate is almost independent of the sample temperature with a value of about 500 ps.
- It is related to larger vacancy clusters.

**As-deformed state**

- Only two lifetime components can be decomposed. Both lifetime components are independent of the sample temperature.
- The lifetime τ₁ is related to larger vacancy clusters.

**Conclusions**

- Two types of positron trapping centers related to larger vacancy clusters (lifetime 500 ps) and dislocation-bound vacancies (lifetime 260 to 300 ps) are introduced during deformation at 800 °C.
- The vacancies on the dislocation line act as deep positron traps, while the regular dislocation line in active as a shallow positron trap.
- After annealing at 800 °C, the positron trapping centers related to vacancy clusters disappear, while dislocation-bound vacancies remain.

- Regular dislocation segments (i.e., shallow positron traps) have a significant influence on positron trapping at low temperatures only in samples deformed at high temperatures.
- The only positron trapping centers observed in the samples deformed at RT are related to vacancy clusters (lifetime 460 ps). In contrast to high-temperature deformation, a void-related positron lifetime even appears after annealing at 1227 °C. It increases from 440 ps after annealing at 800 °C to 570 ps after annealing at 1227 °C.

- The different void-related lifetimes found after deformation at 20 and 800 °C may be interpreted by different sizes of the voids. The smaller size after RT deformation may be related to a lower mobility of dislocations in the glide set, as the dislocation glide giving the dominating mechanism of vacancy supply.

- We previously assumed an increase in the density of voids upon annealing leading to the maximum in the average lifetime around 800 °C. However, this simple interpretation fails with the complicated annealing behavior of sample 3 deformed at room temperature.

- A different core structure may be responsible for the findings that in high-temperature deformed Si dislocation lines act as shallow positron traps and dislocation-bound vacancies as deep traps, while dislocation-related trapping is found in the sample deformed at RT.

- The specific lifetime components in sample 3 can be interpreted by an inhomogeneous distribution of positron traps: 1) regions of a very high density of traps near cracks and 2) regions almost free of positron traps.