Removal of Amorphous Layers by Low Voltage FIB Preparation

A. Graff [a]), M. Simon [a]), F. Altmann [a]),

H. Hoffmeister [b]), P. Gnauck [b])

a) Fraunhofer-Institut für Werkstoffmechanik, Heideallee 19, 06120 Halle (Saale), Germany

b) Carl Zeiss NTS GmbH, Carl-Zeiss-Straße 56, 73447 Oberkochen, Germany

ZEISS

Fraunhofer Institut Werkstoffmechanik

Motivation

For high resolution TEM observations the quality of the sample is important. TEM samples produced by FIB milling often show perturbed contrasts caused by amorphous layers on the side walls of the lamella. The thickness of these layers depends i. a. on the accelerating voltage of the ion gun. This work evaluate the thickness of the amorphous layers at two different ion energies (low (2kV) and high (30kV) voltage) and its dependence on the incident angle. Silicon and gallium arsenide two common materials for microelectronics are selected as examples.

Experimental methods

samples:

Wafers of single crystalline silicon and gallium arsenide were cut into bars and glued onto a TEM half ring. A small area of about 15x10µm^2 was cut out by FIB. The sides of the cuboid were treated by Ga ions with high and low energy (Fig 1 and 2). After irradiation the bar was coated with Platinum by sputtering. Followed by the thinning of the cuboid to electron transparence.

Imaging with 2kV Ga-Ions:

For the low voltage preparation of TEM lamellas the observation of the sample is essential. Due to new ion source designs it is possible to get clear ion induced SE images even at low energies like 2 keV (Fig. 3)

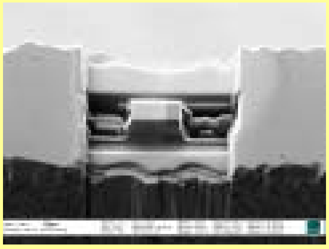

Fig. 1: SEM Overview FIB prepared cuboid

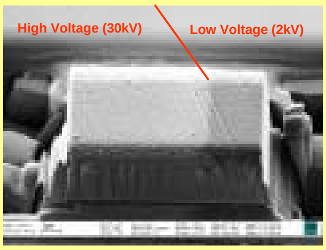

Fig. 2: SEM removal of amorphous layer by low voltage Ga ions

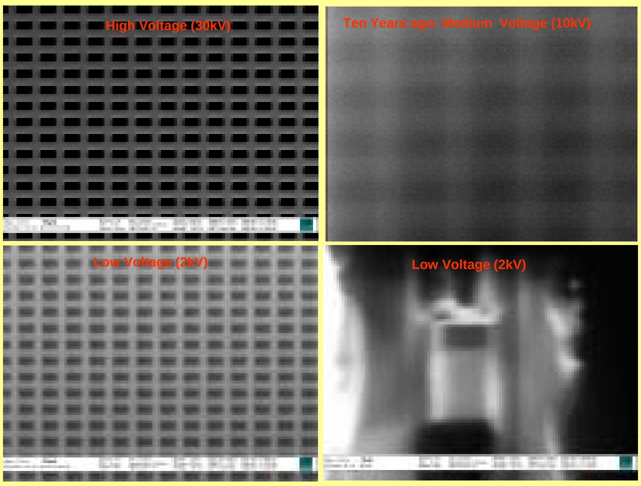

Fig. 3: Quality of ion induced SE images for different accelerating voltages and instrumentation

Acknowledgement

The financial support of Carl Zeiss NTS GmbH is gratefully acknowledged.

Results

TEM: Silicon after Ga ion irradiation from top

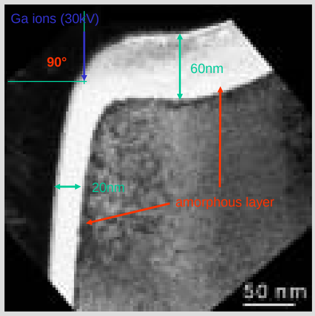

Fig. 4: TEM cross-section: Formation of a thick amorphous layer due to 30kV Ga ion irradiation.

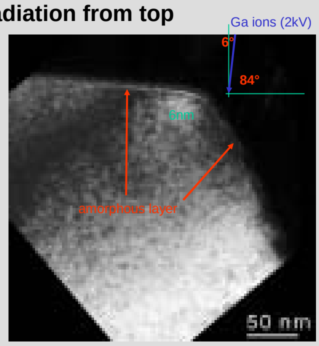

Fig. 5: TEM cross section: Reduced amorphous layer by 2kV Ga ions from top

TEM: Silicon after Ga ion irradiation from side:

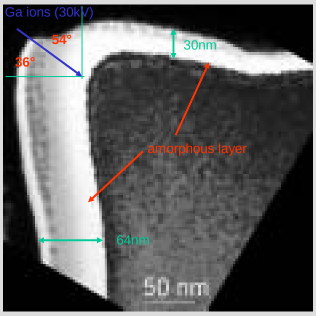

Fig. 6: TEM cross-section: Amorphous layer formed by Ga irradiation from side

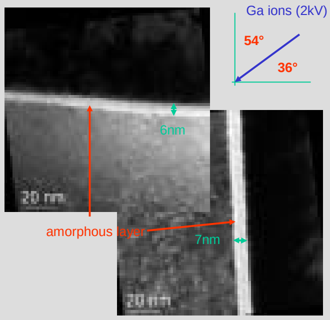

Fig. 7: TEM cross-section: Reduced amorphous layer at top and side by 2kV Ga ions under 54°.

TEM cross sections of GaAs:

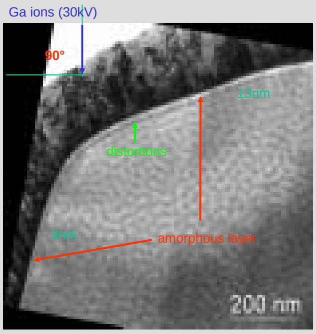

Fig. 8: TEM cross-section: Formation of a amorphous layer and lattice distortions due to 30kV Ga ion irradiation.

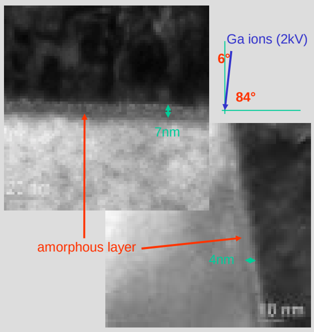

Fig. 9: TEM cross section: Reduced amorphous layer and distorted zone by 2kV Ga ions from top

Summary and conclusion

FIB milling with 30kV Ga ions produce a thick amorphous layer on the surface of the sample. In the case of silicon the thickness varies between 20nm and more than 60nm depending on the angle of incidence. The preparation of TEM lamella with 2kV Ga ions reduce the thickness of the amorphous layers on the surface of silicon to about 6nm. The thickness of the amorphous layer is nearly independent of the angle of incidence. The up to date instrumentation allows the observation of the removal of the amorphous layers in situ during milling. The performance enable this technique to remove the amorphous layers from the viewing direction of the TEM lamella. Even on bended TEM samples the thickness of amorphous layers can be reduced.

contact: Andreas Graff, e-mail: graf@iwmh.fhg.de phone: +49-345-5589-113
Reference: Poster presented at Dreiländertagung 2005, Davos, Switzerland, 29.08.2005, AbstractBook: p.92