FORMING OF MIXED AREA BETWEEN TiO_2 AND SiO_2 AFTER ION IMPLANTATION

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ABSTRACT

The changes in depth distributions of atomic compositions in the structures of $TiO_2/SiO_2/Si$ after ion implantation was investigated. The samples were implanted with Ne^+, Ar^+, Kr^+ and Xe^+ ions at difference energy 100, 150, 200 and 250 keV. Depth profiles of elements in the samples were analyzed by the Rutherford Backscattering Spectrometry (RBS) method [1]. It was found that the mixed layers existed between TiO_2/SiO_2 interface after ion irradiation. The thickness of transition layers increased with growing of ion energy.

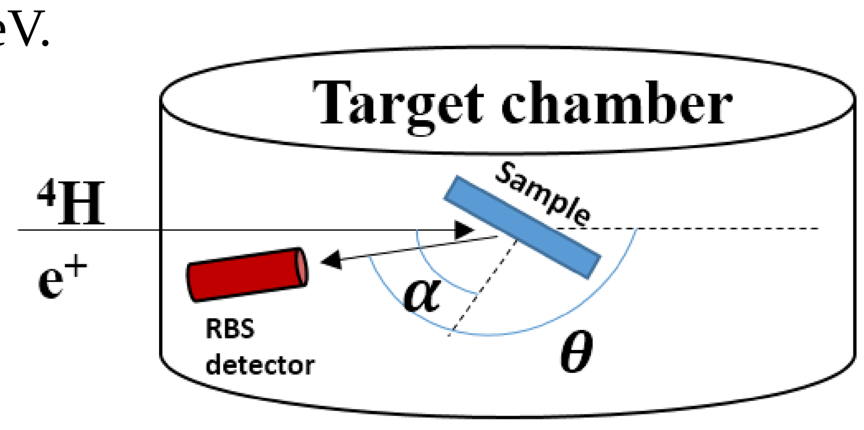
EXPERIMENT

❖ Ion implantation.

The samples irradiated with 4 different ion specimens Ne^+, Ar^+, Kr^+ and Xe^+ at different energy 100, 150, 200 and 250 keV. The samples have been irradiated with the ions at the same fluency $3*10^{16}$ (ions/cm^2) [2].

❖ Analytical method

- The energy of He^+ ion beam: 1.5 MeV.
- The incident angle $\alpha = 60^0$
- Scattering angle $\theta = 170^0$
- Depth profile were calculated using SIMNRA code [3].
- Detector energy resolution 15 keV

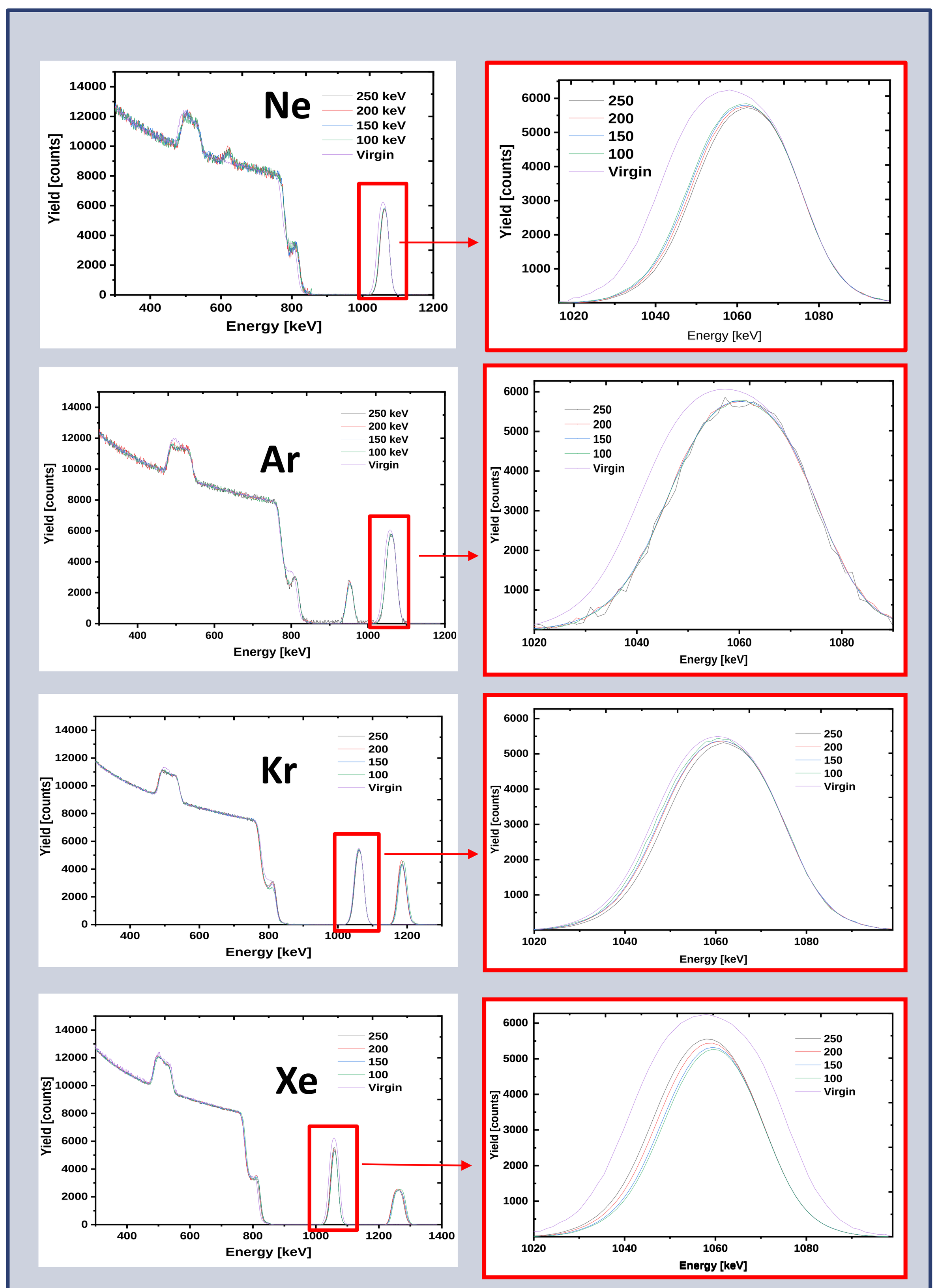


❖ Theoretical calculation

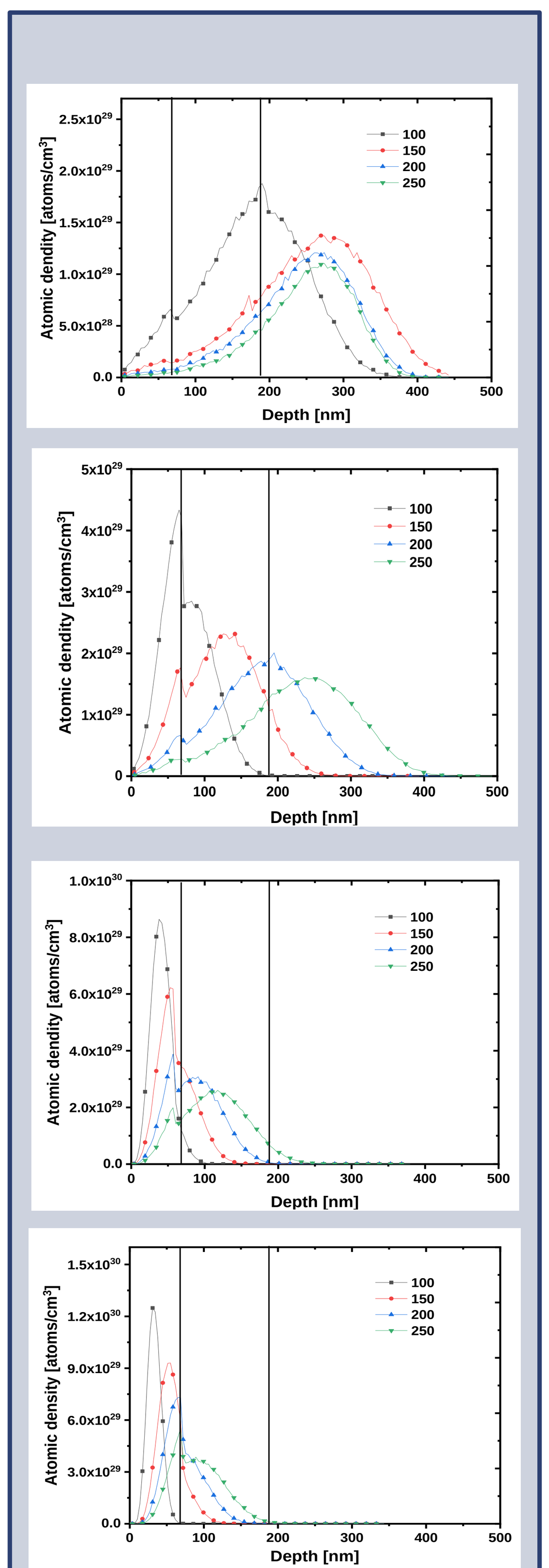
Depth-dependent damage and defect concentration profiles were calculated for understanding and explanation the obtained effects using the Stopping and Range of Ions in Matter (SRIM)-2008 [4].

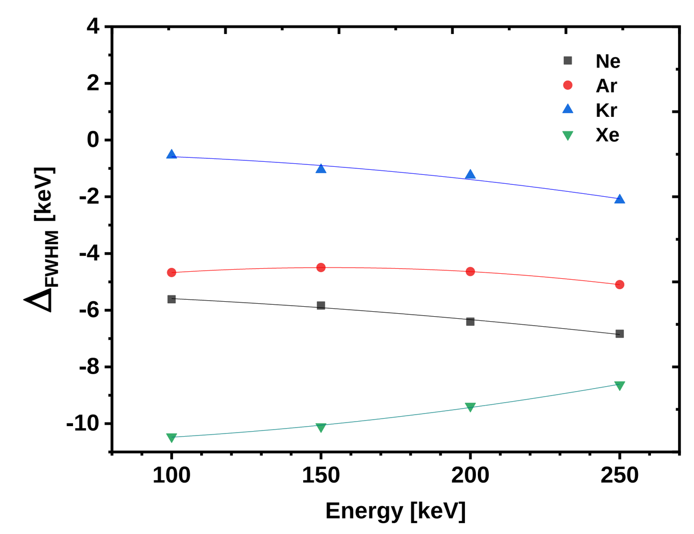
RESULTS

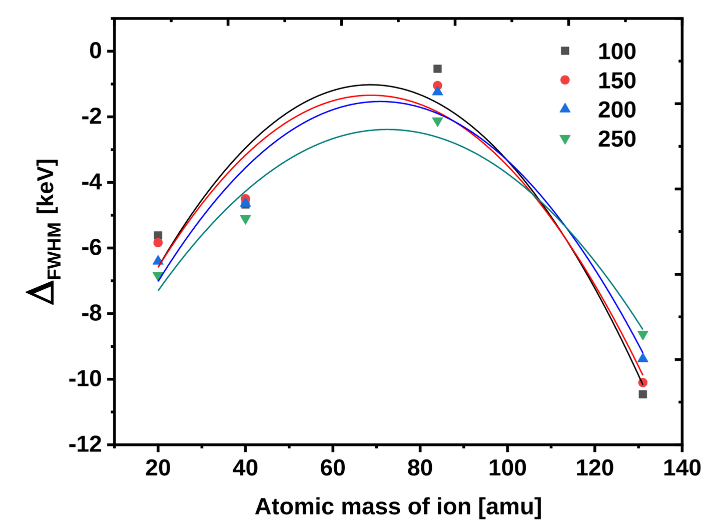
RBS spectra for samples before and after implanted with ions at different energies



The projected range of ions at different energies in TiO_2/SiO_2 samples (SRIM calculation)







The mixing in the samples is best characterized by an error function [5]:

$$C(x) = \frac{C_s}{2\sqrt{\pi D t}} \exp\left[\frac{-(x-x_0)^2}{4Dt}\right]$$

where

$C(x)$ is the Ti atom concentration at location x,
C_s is the initial Ti atom concentration,
D is the ***effective diffusion coefficient*** and
x_0 is the position of the initial Ti film.

$$D = \frac{\sigma^2 - \sigma_0^2}{2t}\left(\frac{\delta E}{[\varepsilon_0]_{SiO_2} N_{SiO_2}}\right)^2$$

Δ^2 = (FWHM)^2 - (FWHM)$_0^2$ = $2.34^2(\sigma^2 - \sigma_0^2)$

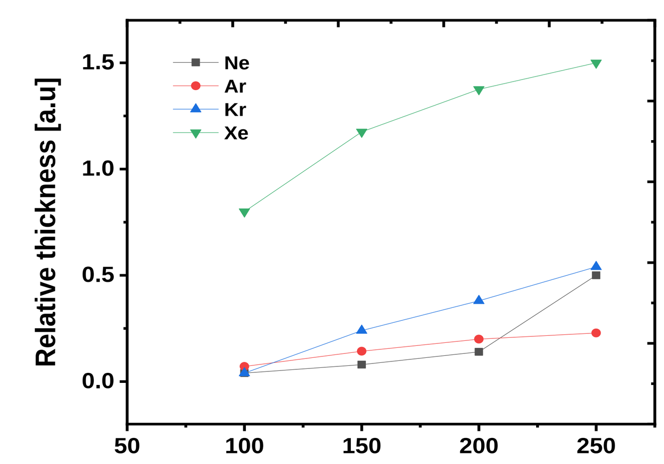
These equation implies that:

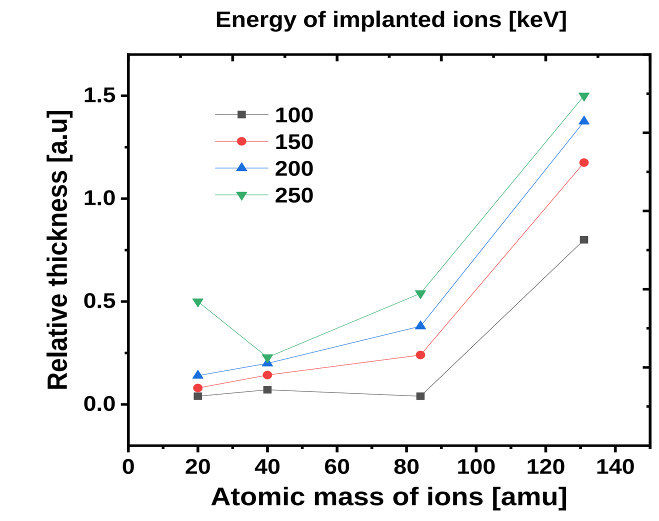
$$\mathbf{D} \propto \Delta$$

The relative changing thickness of the transition layers before and after ion

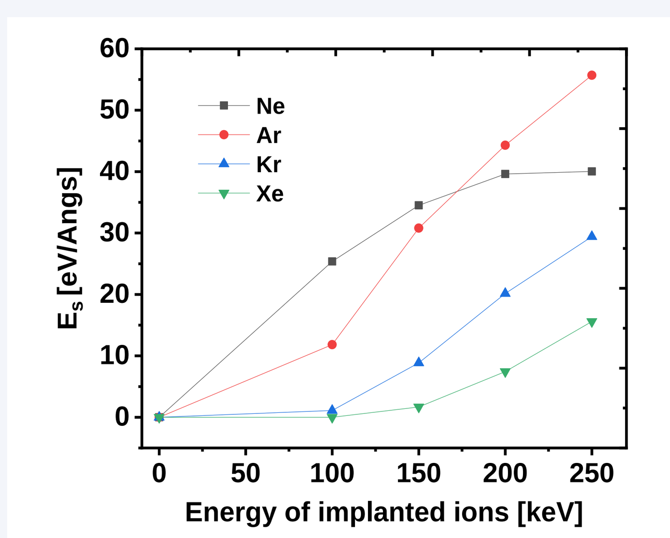
$$r_t = \frac{t_{im} - t_{vir}}{t_{vir}}$$

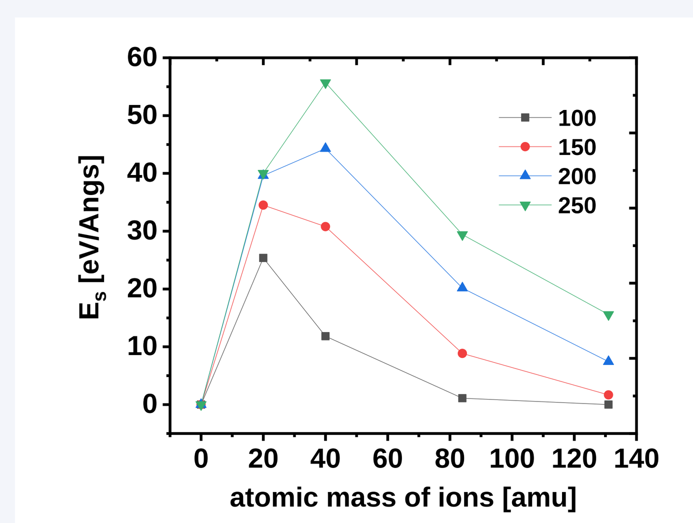
Where r_t is the relative changing thickness of the transition layers,
t_{im} is thickness of the transition layers in samples after implantation,
t_{vir} is thickness of the transition layers in virgin samples - before implantation.



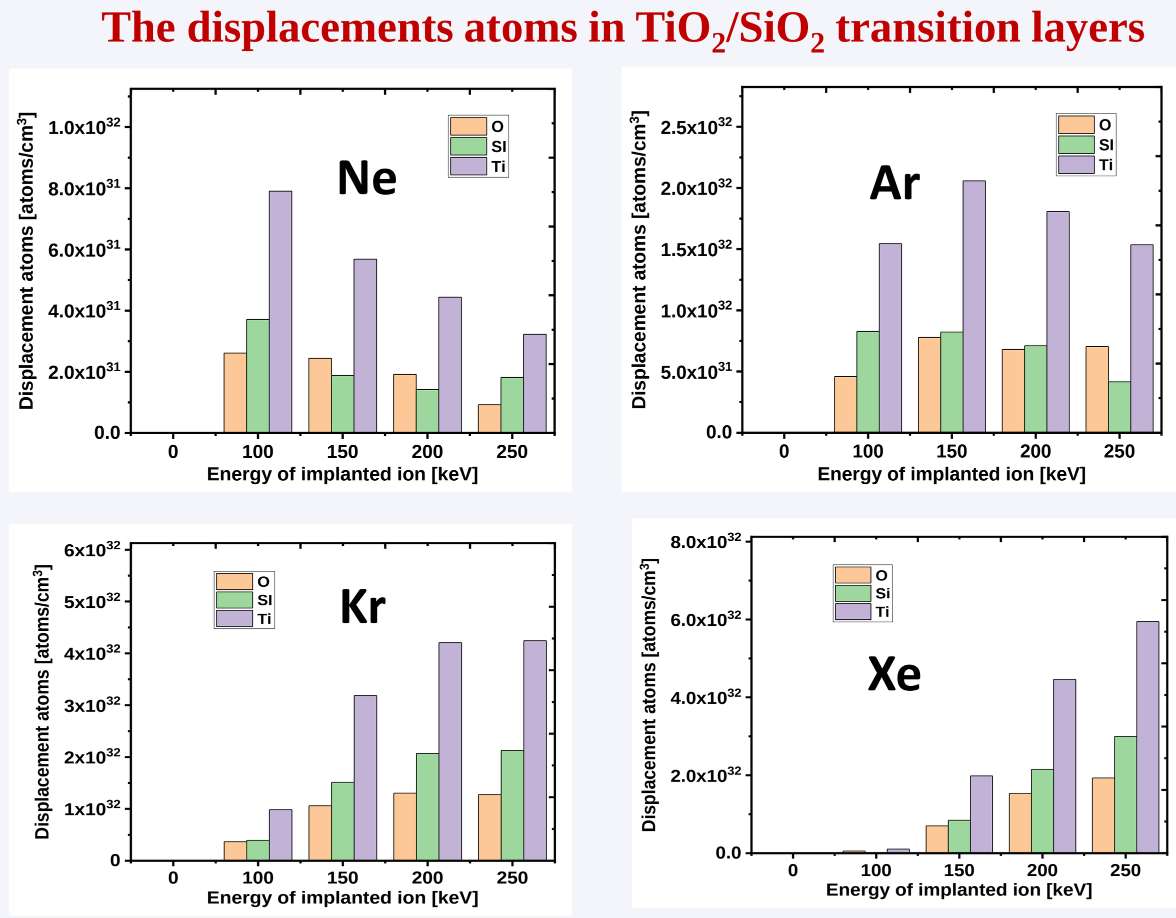


The energy loss of ions in the TiO_2/SiO_2 transition layers





The displacements atoms in TiO_2/SiO_2 transition layers



REFERENCE

[1]. W.K. Chu, J.W. Mayer, M.A. Nicolet, Backscattering Spectrometry, Academic Press, New York San Francisco London, 1978.
[2] M. Turek, S. Prucnal, A. Drozdziel, K. Pyszniak, Versatile plasma ion source with an internal evaporator, Nucl. Instrum. Methods Phys. Res. B, 269, 7, (2011), 700-707.
[3] M. Mayer, SIMNRA User's Guide, Report IPP 9/113, Max-Planck-Institut für Plasmaphysik, Garching, Germany, 1997.
[4] J.F.Ziegler, J.P.Biersack and M.D.Ziegler, SRIM-The Stopping and Range of Ions in Matter, SRIM Co, Ion Implantation Press, Chester, 2008.
[5] M. G. Scott and R. A. Collins, G. Dearnaley, Radiation Enhanced Diffusion In Kr+ bombarded Ni-Yb films, Rudiafion Efecrs. 1984, Vol. 81. Pp. 211-219.

CONCLUSIONS

-Thickness of the transition layers increase with growing energy of implanted ions.
- Speed of increasing the thickness of mixed layers depends on ions mass.
- For the cases of Kr^+ and Ar^+ ion irradiation, thickness of transition layers increase as a linear function of ion energy.