

Electron Beam Transformation of Glass Nanoparticles

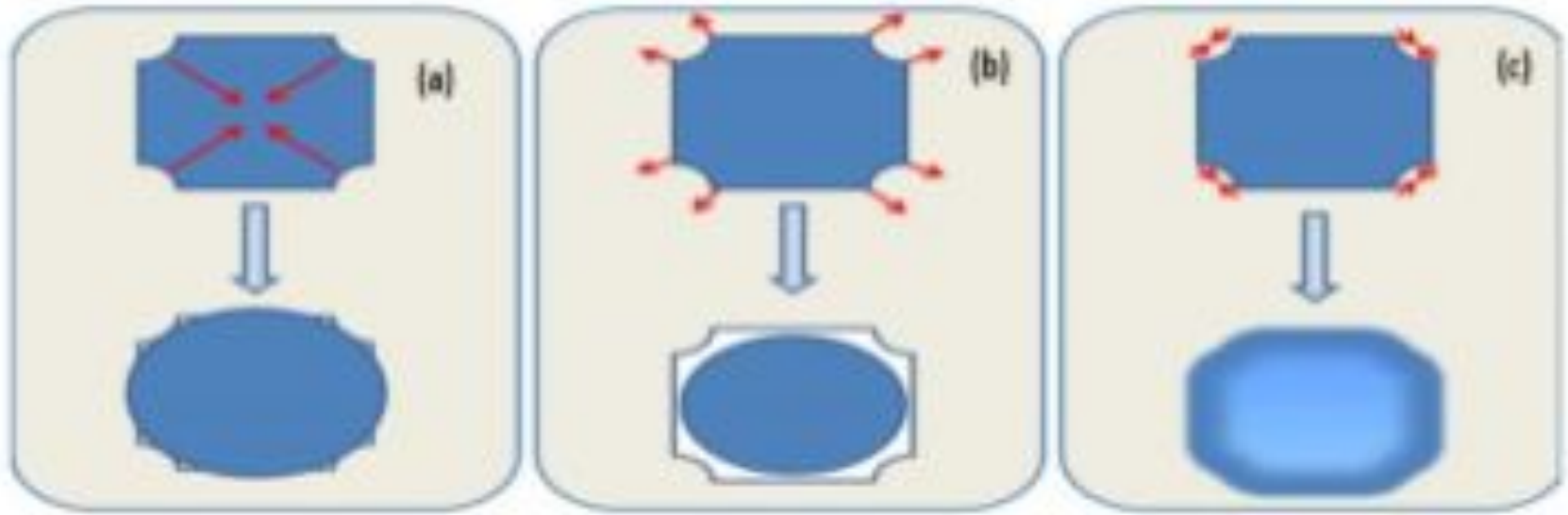
Mohammed Faeq M. Sabri
Guenter Moebus

Department of Physics, Faculty of Science and Health, Koya University Koya KOY45, Kurdistan Region –
F.R. Iraq

Department of Materials Science and Engineering, The University of Sheffield, Sheffield, UK, S1 3JD

The phenomenon of electron irradiation induced quasi-fluid flow in solid amorphous silicates is examined. High-intensity electron beam irradiation of glass nanoparticles in TEM leads to a variety of transformations including rounding, bead formation and phase separation. Evidence for possible rise in temperature, charging fields and enhanced diffusion is collected and compared, while the latter effect (loosening of glass network) is shown to dominate.

- (a) centripetal surface tension with sphere formation under volume conservation,
- (b) electric field enhancement at corners and ablation leading to rounding under volume loss;
- (c) surface diffusion leading to rounding with overall shape conservation.

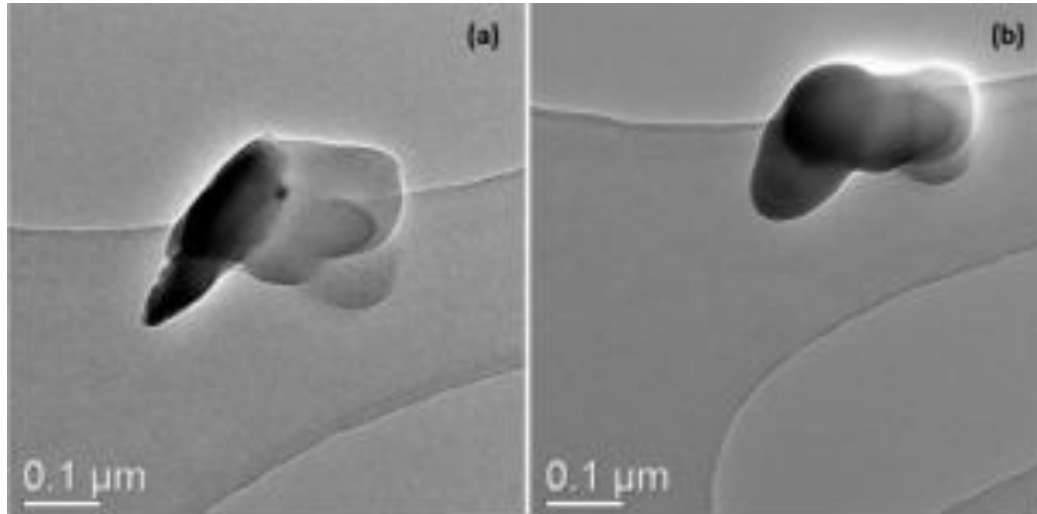


Schematic of 3 possible glass particle transformation mechanisms by electron irradiation

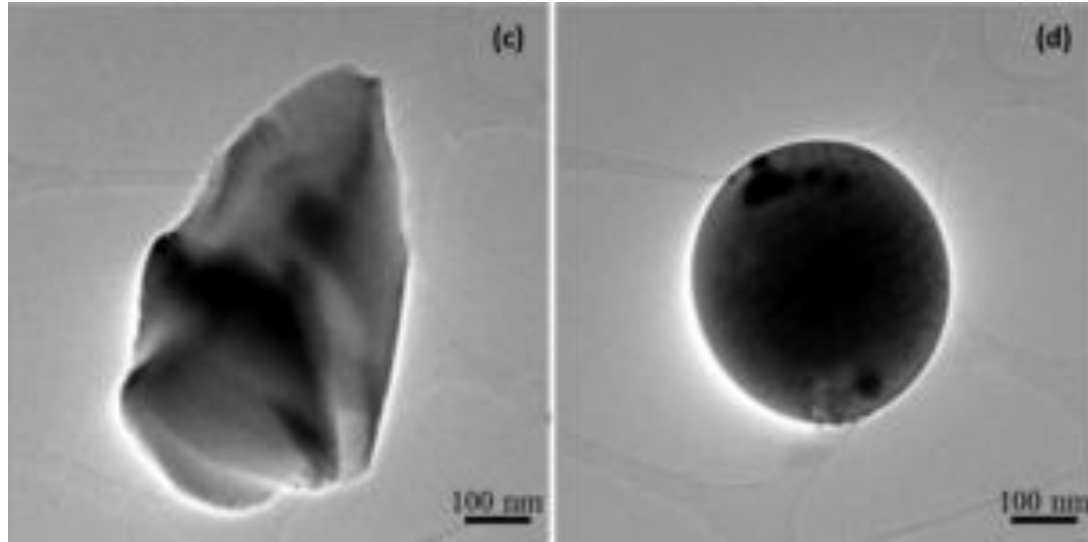
Table: Chemical compositions of glass (mol.%).

Glass	Compositions (mol.%)								
	B ₂ O ₃	SiO ₂	Na ₂ O	Li ₂ O	CeO ₂	Cr ₂ O ₃	ZrO ₂	CuO	ZnO
NBS	20	63.4	16.6	0	0	0	0	0	0
NLBS-CCZ	25.7	51.4	8.6	4.3	4	2	4	0	0
Cu-NBS	15	50	15	0	0	0	0	20	0
Zn-BS	20	20	0	0	0	0	0	0	60

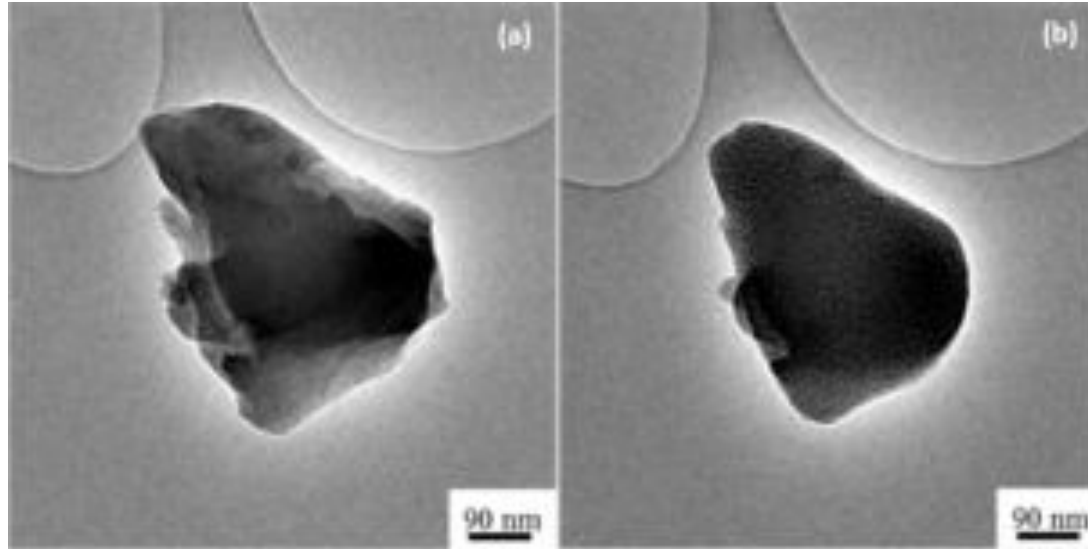
Slow particle rounding



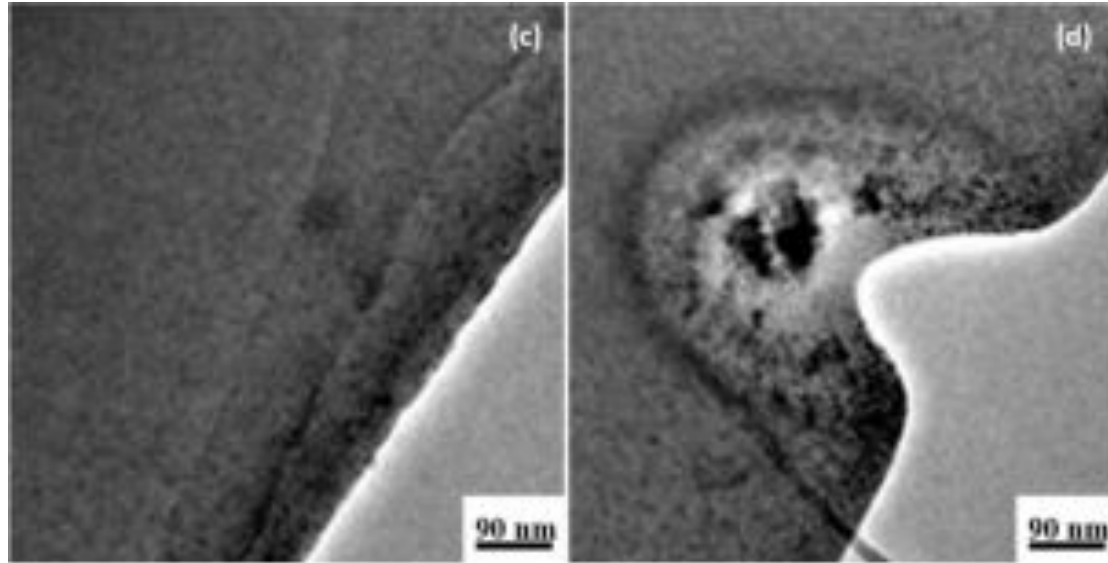
Fast bead formation



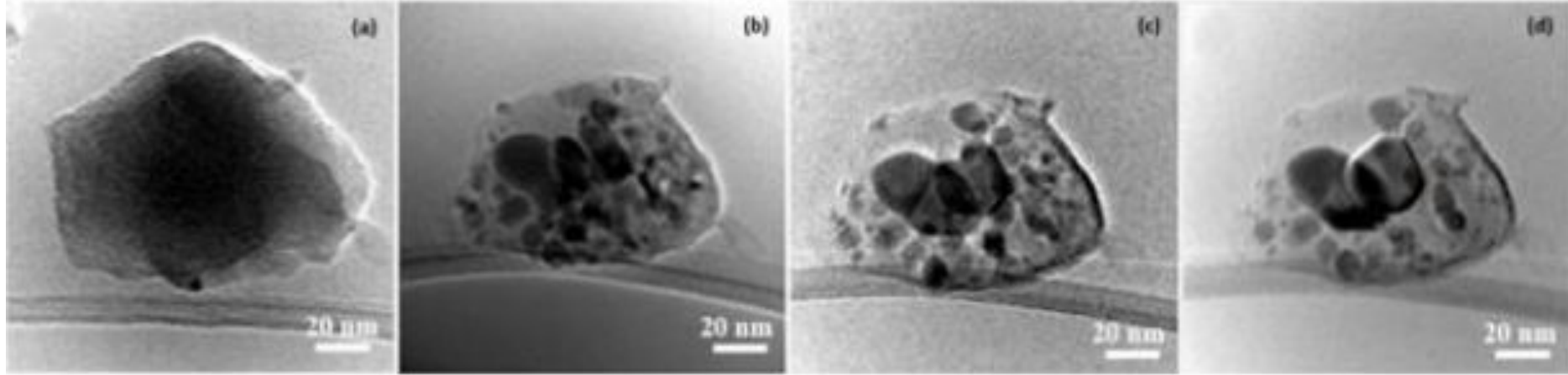
De-homogenisation



De-homogenisation



Heating holder TEM



Mohammed Mohammed Sabri, G. Möbus: New insight into nanoparticle precipitation by electron beams in borosilicate glasses. Applied Physics A 123(6).

Conclusions

The observed effects are of importance for glass-surface engineering (both smoothing and - via phase separation - roughening could be achieved), but also for improving wetting-behaviour, for defect healing (low-temperature “annealing”), or changing porosity characteristics in nanoporous glasses, and ultimately also for glass patterning and grating formation.