Effect of 200 MeV Ag Swift Heavy Ions on Electrical Transport Property of $Y_{1-x}Ca_xBa_2Cu_3O_{7-\delta}$ Composite Thick Films

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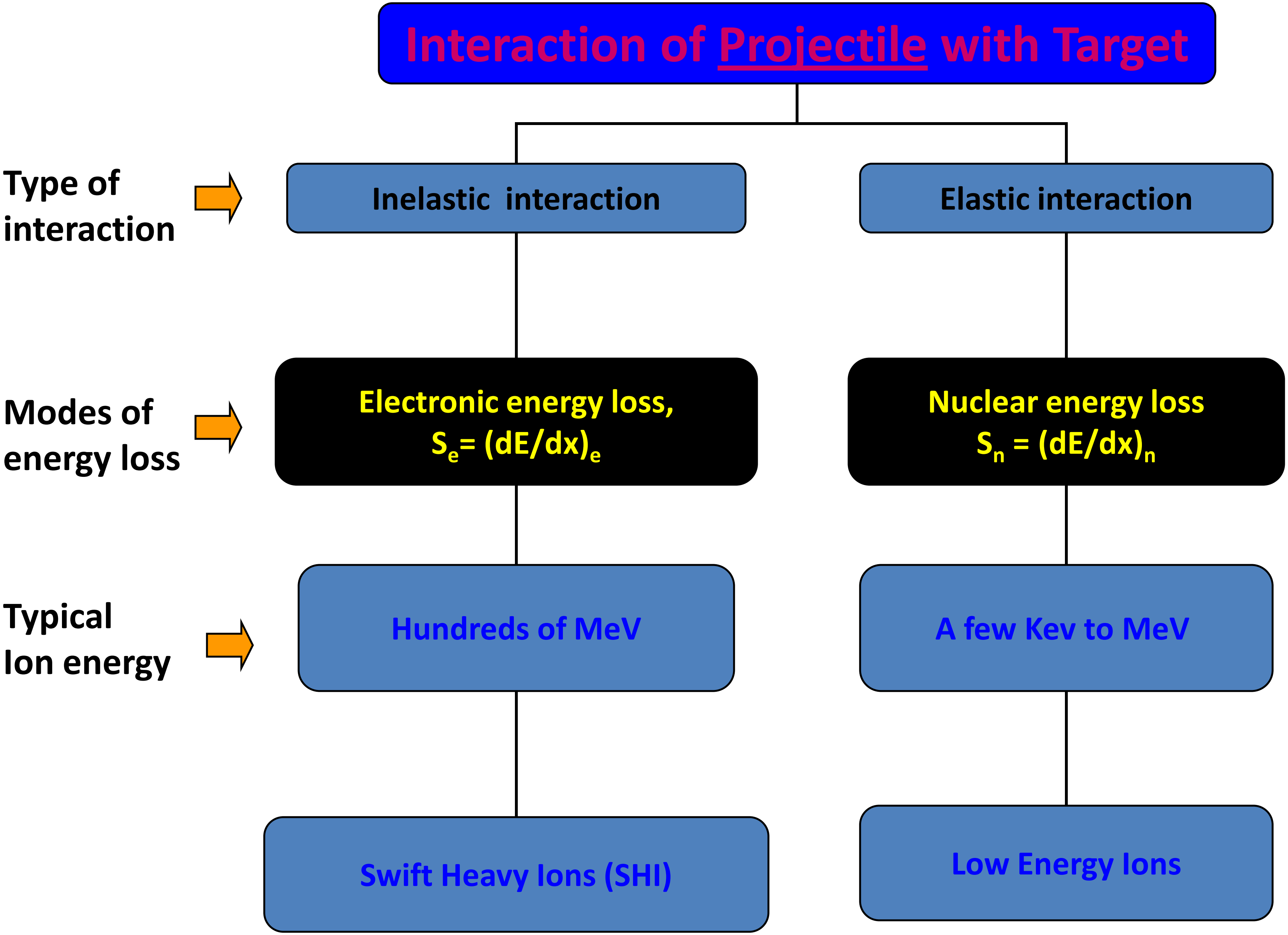
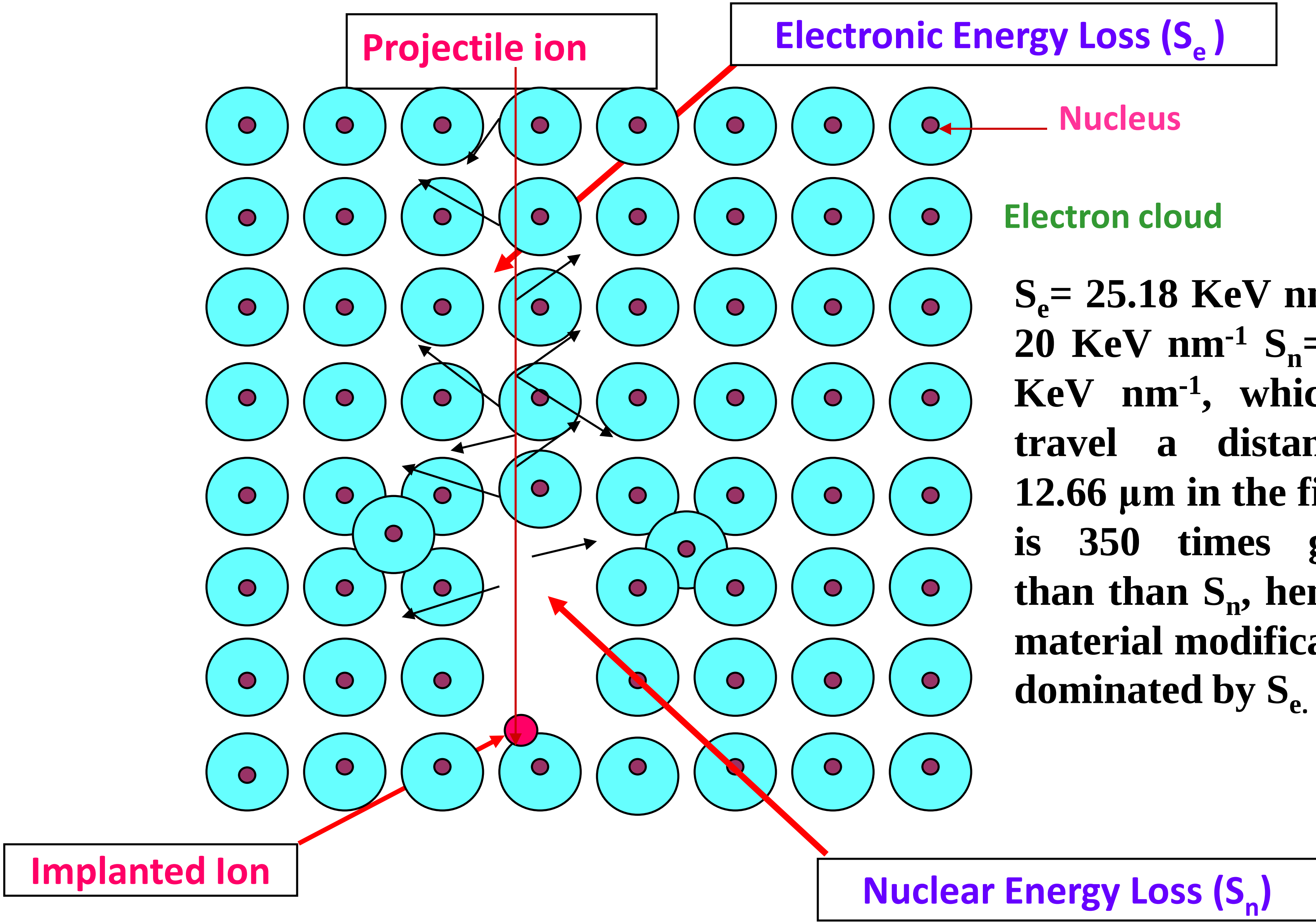
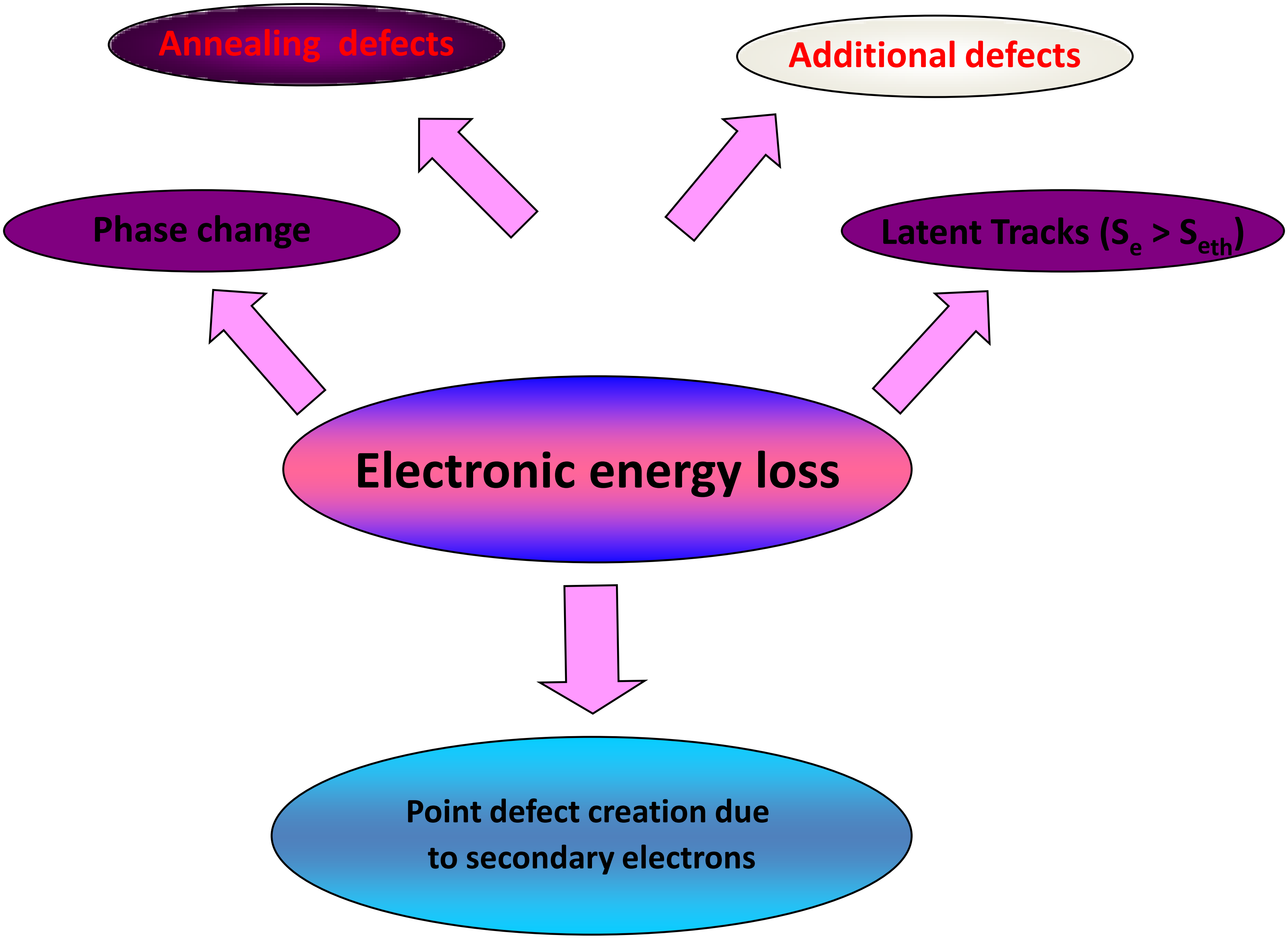

Interaction of Projectile with Target
Type of interaction
Inelastic interaction
Elastic interaction
Modes of energy loss
Electronic energy loss,
$S_e = (dE/dx)_e$
Nuclear energy loss
$S_n = (dE/dx)_n$
Typical Ion energy
Hundreds of MeV
A few Kev to MeV
Swift Heavy Ions (SHI)
Low Energy Ions



S_e= 25.18 KeV nm^{-1} S_{th}= 20 KeV nm^{-1} S_n= 0.071 KeV nm^{-1}, which can travel a distance of 12.66 µm in the film. S_e is 350 times greater than than S_n, hence the material modification is dominated by S_e.


Annealing defects
Additional defects
Phase change
Latent Tracks ($S_e > S_{eth}$)
Electronic energy loss
Point defect creation due
to secondary electrons

Experimental

Sample Preparation

Thick film by diffusion reaction technique

Substrate Y211+ Ca (green phase)

Overlayer $Ba_3Cu_5O_8$

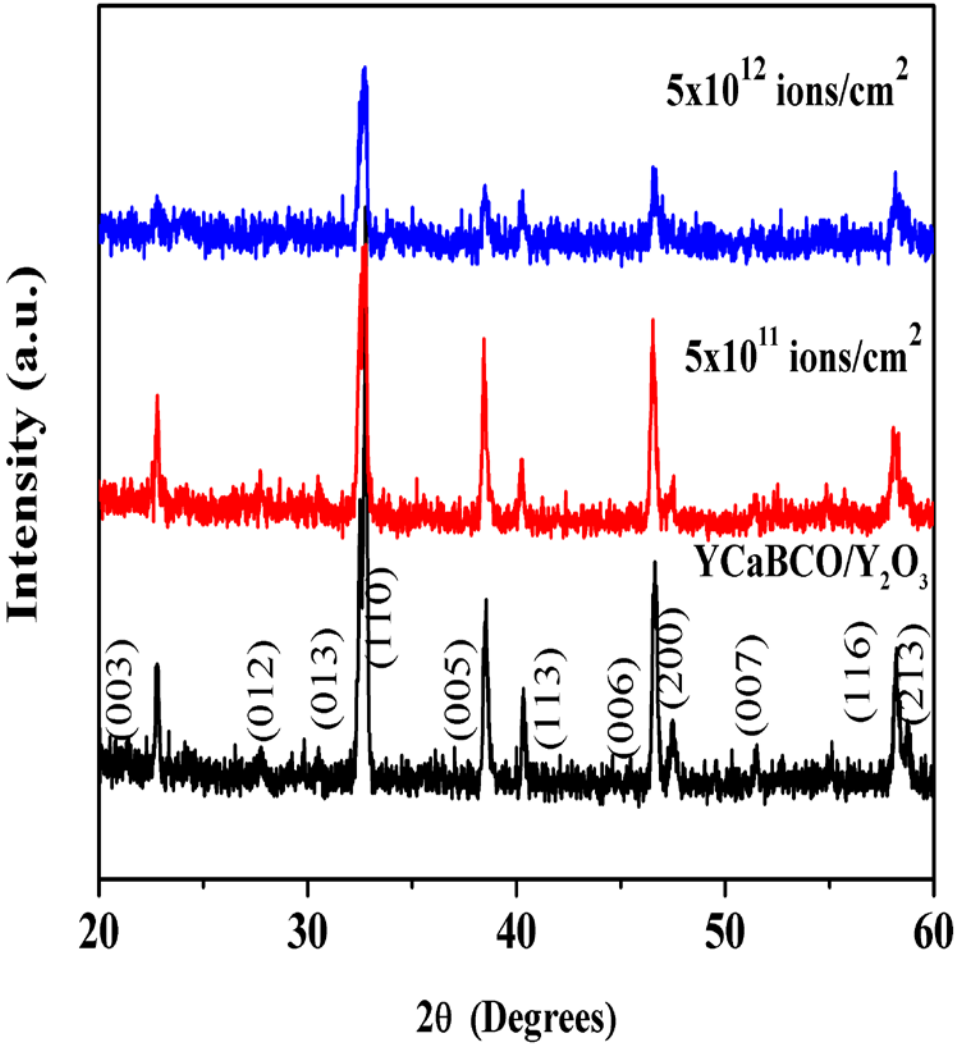
$Y211+Ca+Ba_3Cu_5O_8$ → YBCO

$Y211+Ca+Ba_3Cu_5O_8+Y_2O_3$ → $YBCO + Y_2O_3$

Irradiation of Thick film by 200 MeV Ag ions of Fluence

- **5×10^{11} ions/cm^2**
- **5×10^{12} ions/cm^2**

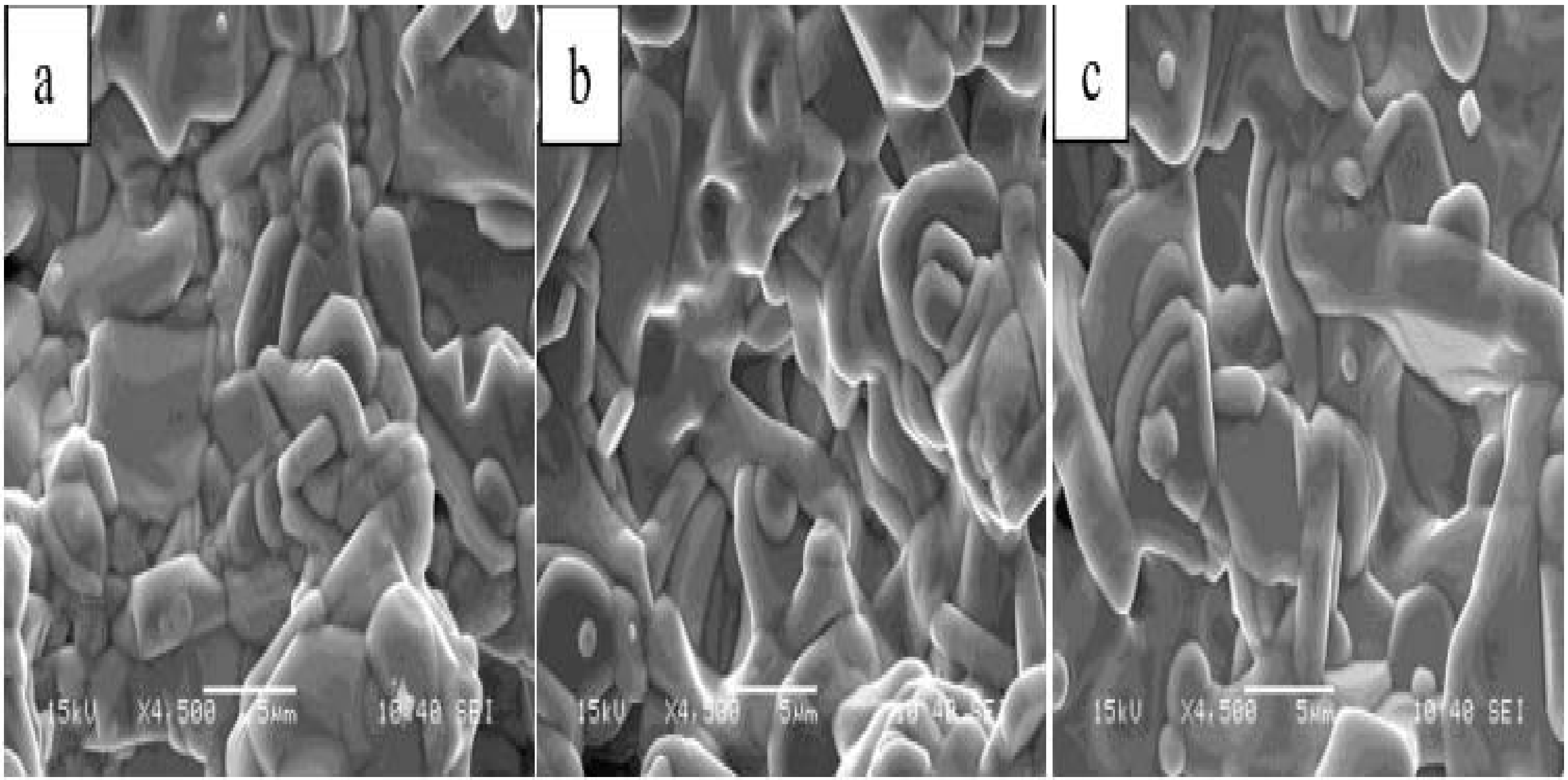
Structural analysis (XRD)



- Peaks corresponds to YBCO phase corresponding to space group P*mmm* orthorhombic.
- (00*l*) peak intensity falls as a function of ion fluence
- Decreases the crystalline volume fraction effecting peak intensity to decrease
- Fall in intensity is due to defect production via secondary electrons creating point defects.

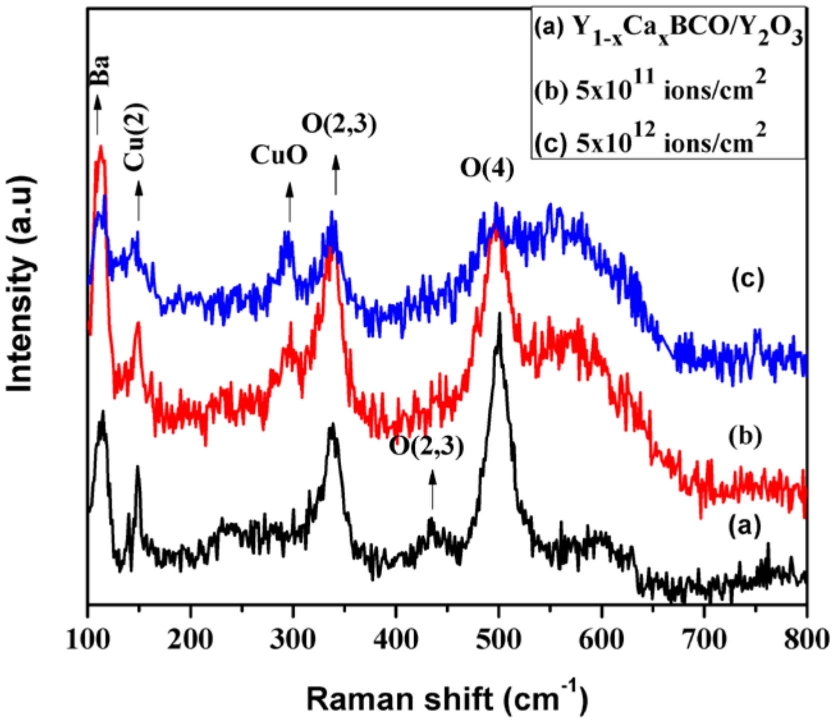
- Elongation of *c* axis

Structural analysis (SEM)



Densely packed well distributed grains
are observed in all the samples

Raman Analysis



~500 cm^{-1} (stretching of apical oxygen ,

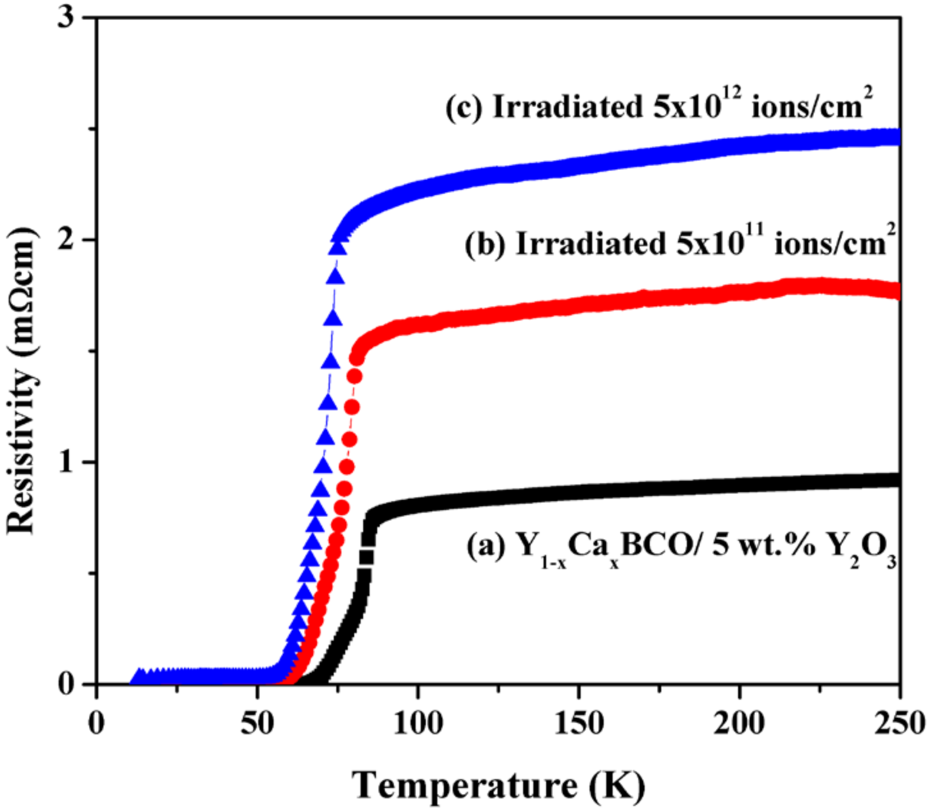
~ 440 cm^{-1} (in phase vibration of O (2) –O (3) oxygen atom in CuO_2),

~337 cm^{-1} (out-of-phase *c* axis vibration of O (2) –O (3) oxygen atom in CuO_2 plane).

The other two Raman active modes are vertical along the *c* axis given by Ba atoms (~116 cm $^{-1}$) and Cu (2) atoms(~154 cm^{-l})

600 cm^{-1} is associated with defects and oxygen vacancies.
oxygen suppression is occurring on the apical site.

Electrical transport property



The ratio of ρ_{250K}/ρ_{100K} is ~1 indicating that the fall of resistance is decelerated.

Increase the residual resistivity (ρ_o) .

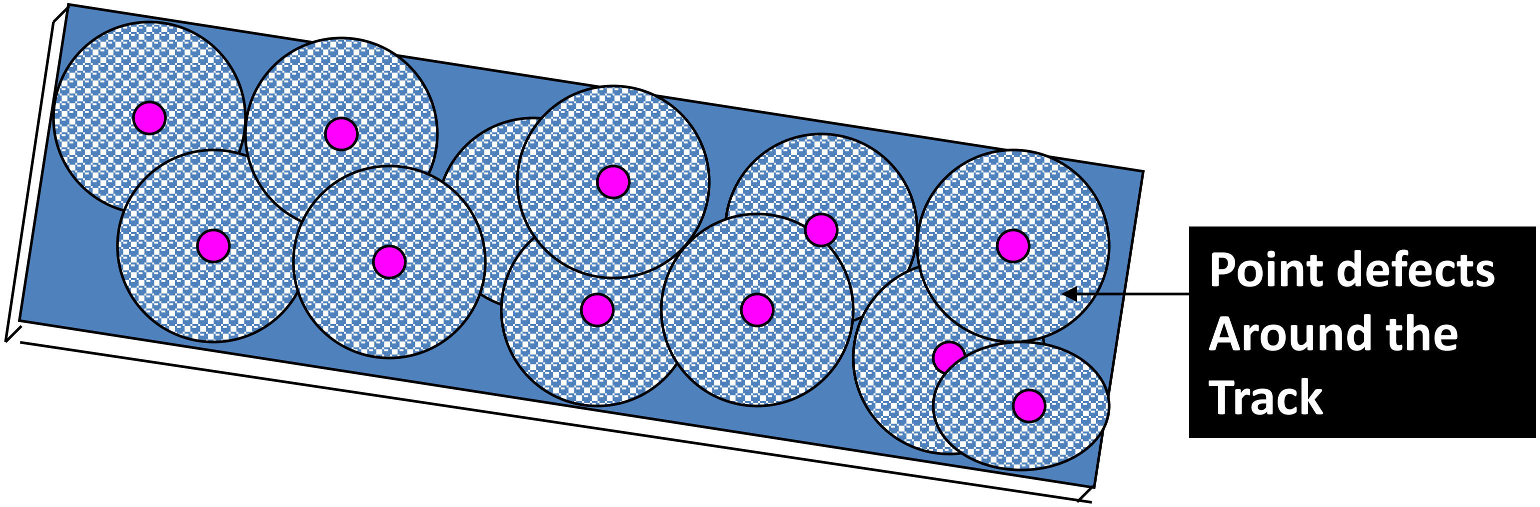
Resistive properties of the samples

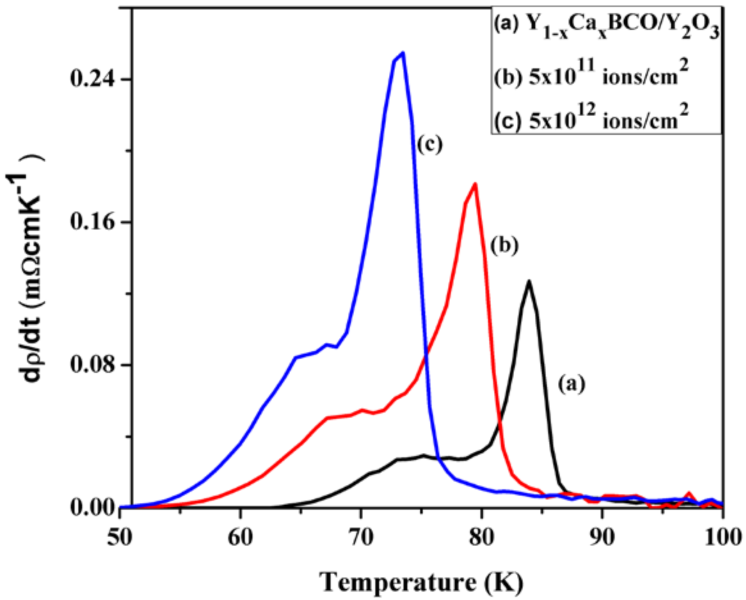
Samples	T_{cmf} (K)	T_{c0} (K)	ρ_{250K} (mΩcm)	ρ_{100K} (mΩcm)	ρ_0 (mΩcm)
YCaBCO/5wt. %Y_2O_3	83.94	63.37	0.919	0.81	0.792
$\Phi = 5x10^{11}$ ions/cm^2	79.27	54.21	1.807	1.61	1.557
$\Phi = 5x10^{12}$ ions/cm^2	73.09	51.01	2.451	2.22	2.219

Our results → T_c decreases

↓

Point defects are created by SHI induced secondary electrons around the latent track



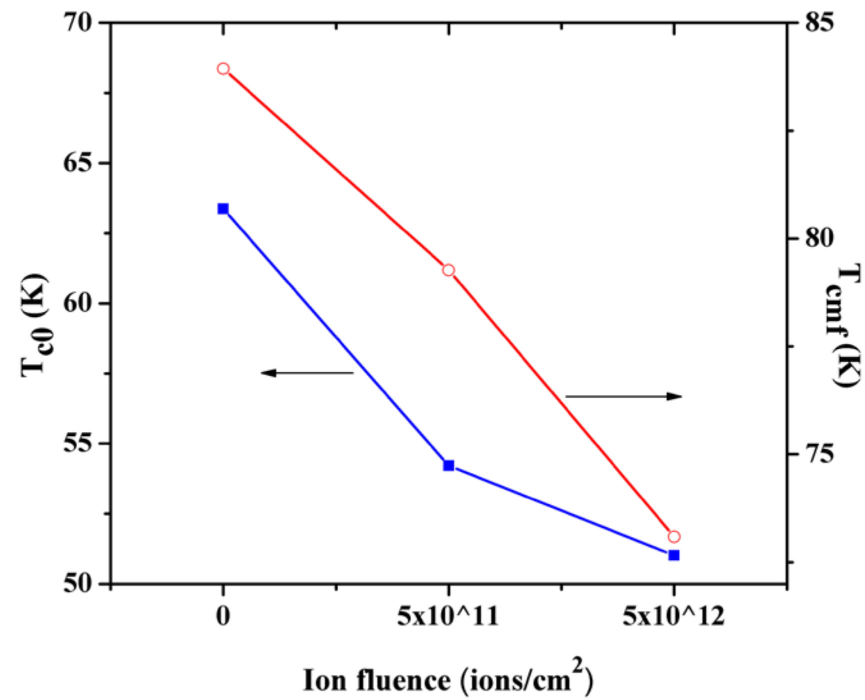


A finite tailing is observed in the derivative plot

Asymmetry of dρ/dT peak gives us valuable information about grain boundaries being damaged more than the grain itself

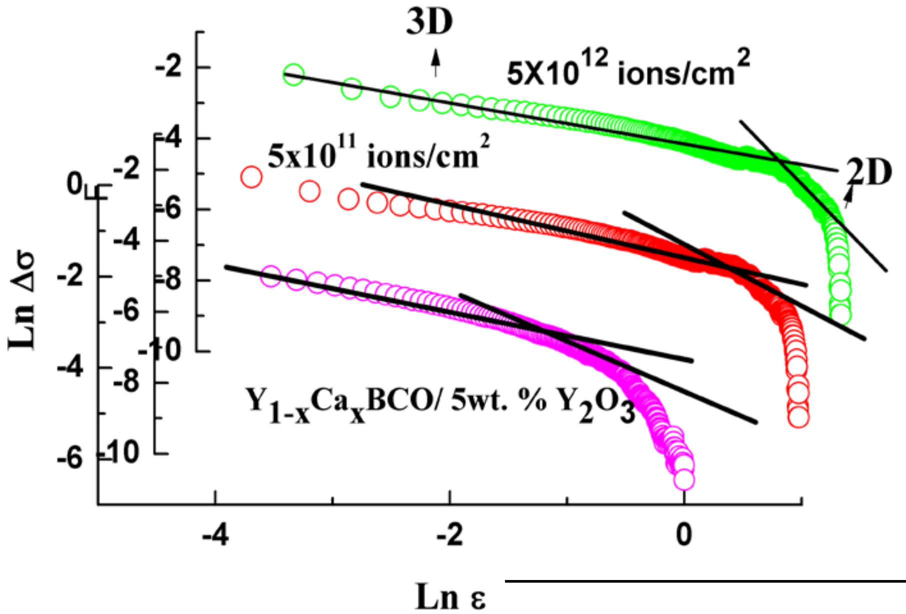
T_{cmf} decrease is accounted by vacancy created in CuO chains due to irradiation.

The onset of global superconductivity i.e. T_{c0} drastically reduces.



Excess conductivity

$$\Delta\sigma = (1/\rho_m - 1/\rho_n) = A\,\varepsilon^{-\lambda}$$



T_{LD}, T_{SWF} changes and 2D regime dominate the flow of activated charge carriers in irradiated samples.

Samples	λ_{SWF}	λ_{2D}	λ_{3D}	T_{SWF} (K)	T_{LD} (K)	T* (K)	ξ(nm)	J
YCaBCO/5wt. %Y_2O_3	2.70	.49	1.01	127.45	100.20	173	2.57	0.19
Φ = $5x10^{11}$ ions/cm^2	3.10	.49	1.05	133	105.75	167	3.37	0.33
Φ = $5x10^{12}$ ions/cm^2	2.85	.49	0.88	146	91.52	163	2.93	0.25

Conclusion

- **Increment of residual resistivity**
- **Decrement of transition temperature**
- **Significant broadening in transition**
- **The dominance of 2D regime on irradiation**
- **The shifting of the apical oxygen O (4) atom towards the lower frequency side**
- **Oxygen loss confirmed by Raman**
- **(00l) Peak intensity decreases as a function of fluence**


Thank you ...