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High rate deposition of highly conductive ITO thin films by a new 3-D magnetron source near room temperature

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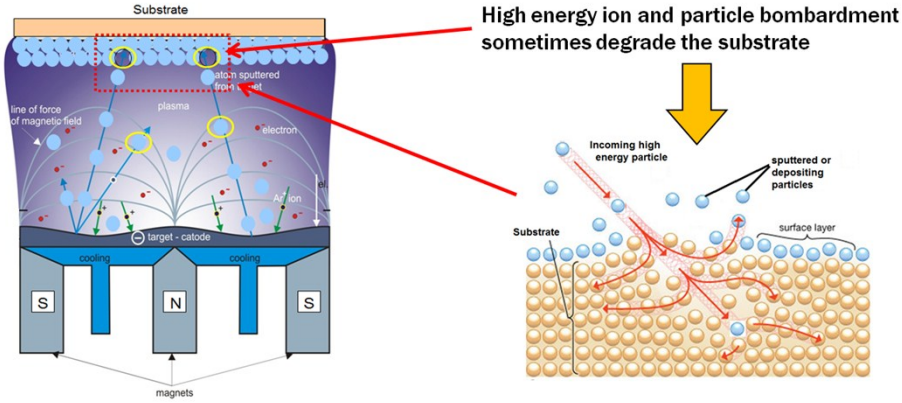
Supplementary information

Some difficulties/disadvantages of magnetron sputtering

➢ At high plasma density and high deposition rate



- Materials or thin films are degraded by high energy atom and ion bombardments
  → **Lead increase substrate temperature and damage**
- Complexity of plasma based process and process control is not straightforward
- **It is also challenging for the crystallization of the film at low-temperature < 100°C**

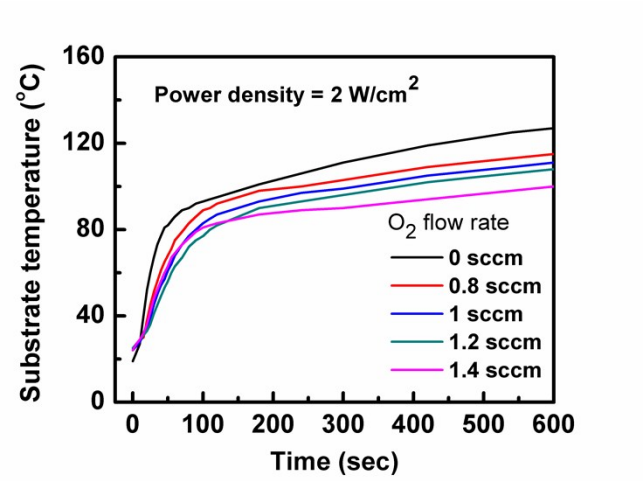
Our key demands /requirements

Our demand on process and material	Necessity
Process requirement ▪ High rate deposition ▪ High target efficiency and large area deposition ▪ Low-temperature deposition process ▪ Cost-effective fabrication **Material aspect** • Good crystallinity • High conductivity in ultra thin film • Film adhesion and flexibility • High transmittance	➢ New-type and high density plasma source ➢ Control of plasma parameters (electron temperature, plasma density, etc.) ➢ Energy control of sputtered particles and ions ➢ Process understanding, optimization, and control by diagnostics ➢ To reduce/clean amorphization or to enhance crystallinity by reducing ion flux on the substrate (need good charge trapping). ➢ To find the way to sputter a bunch of atoms or to form clusters to add up crystallinity at low-temperature.

- There is the need of advance plasma process with new-type of sources.
- There is the need of integrated study of film properties and plasma chemistry

Deposition of ITO films using 3DMS

Low-temperature Deposition



200 nm Film deposition time ≤ 114 Sec

Photo: Magnetron sputtering of ITO films