IBAD MgO Templates for YBCO Coated Conductors

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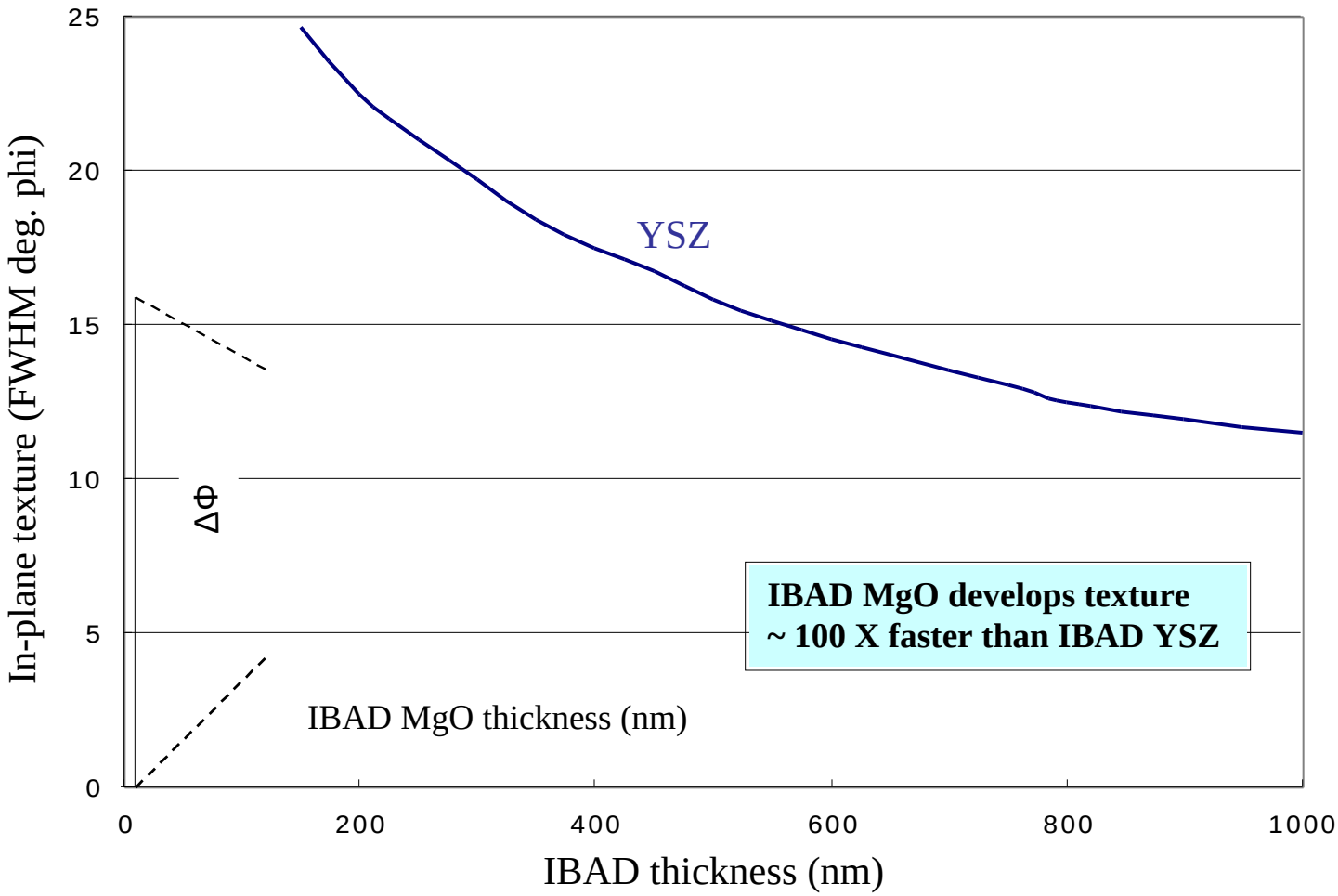
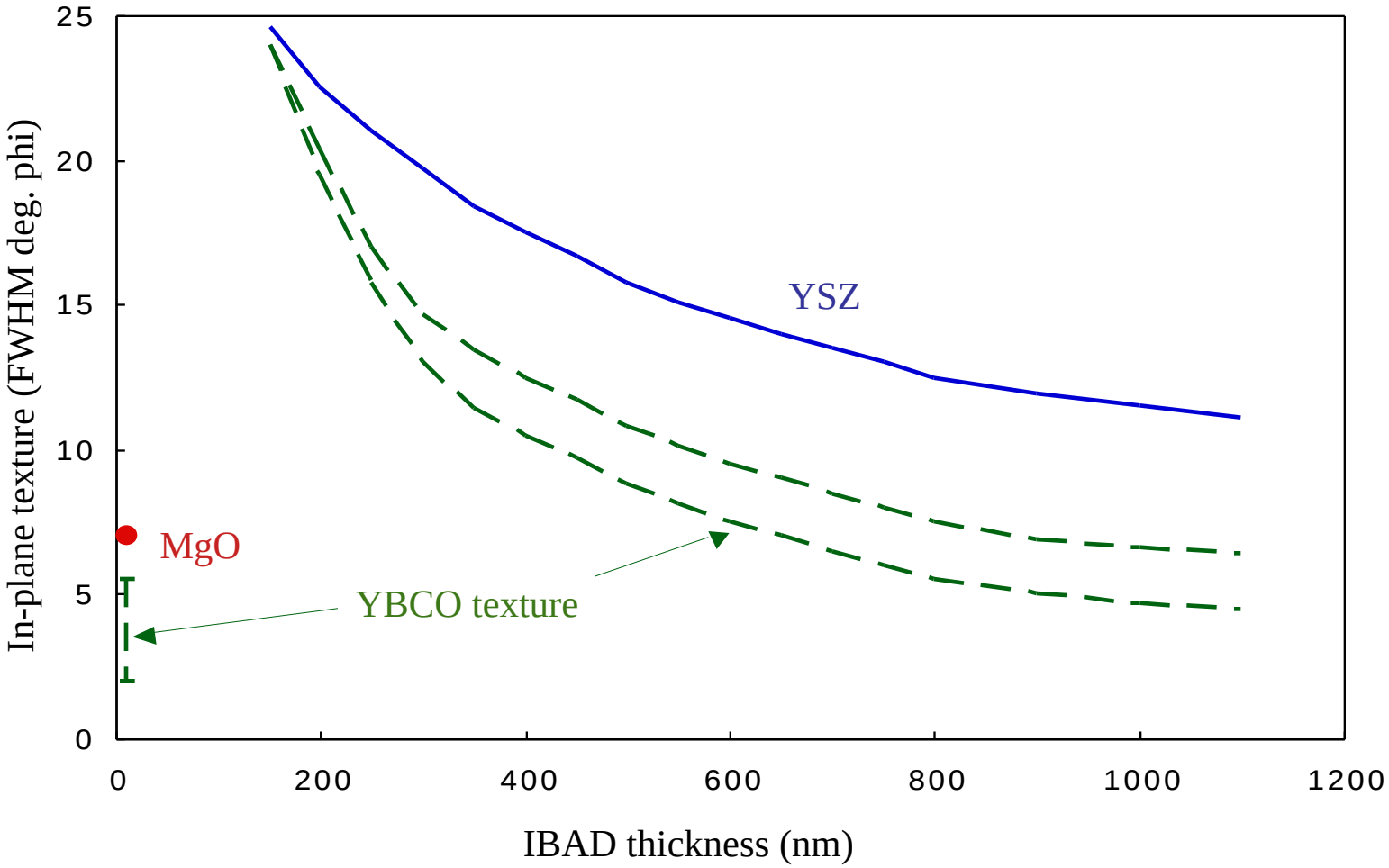
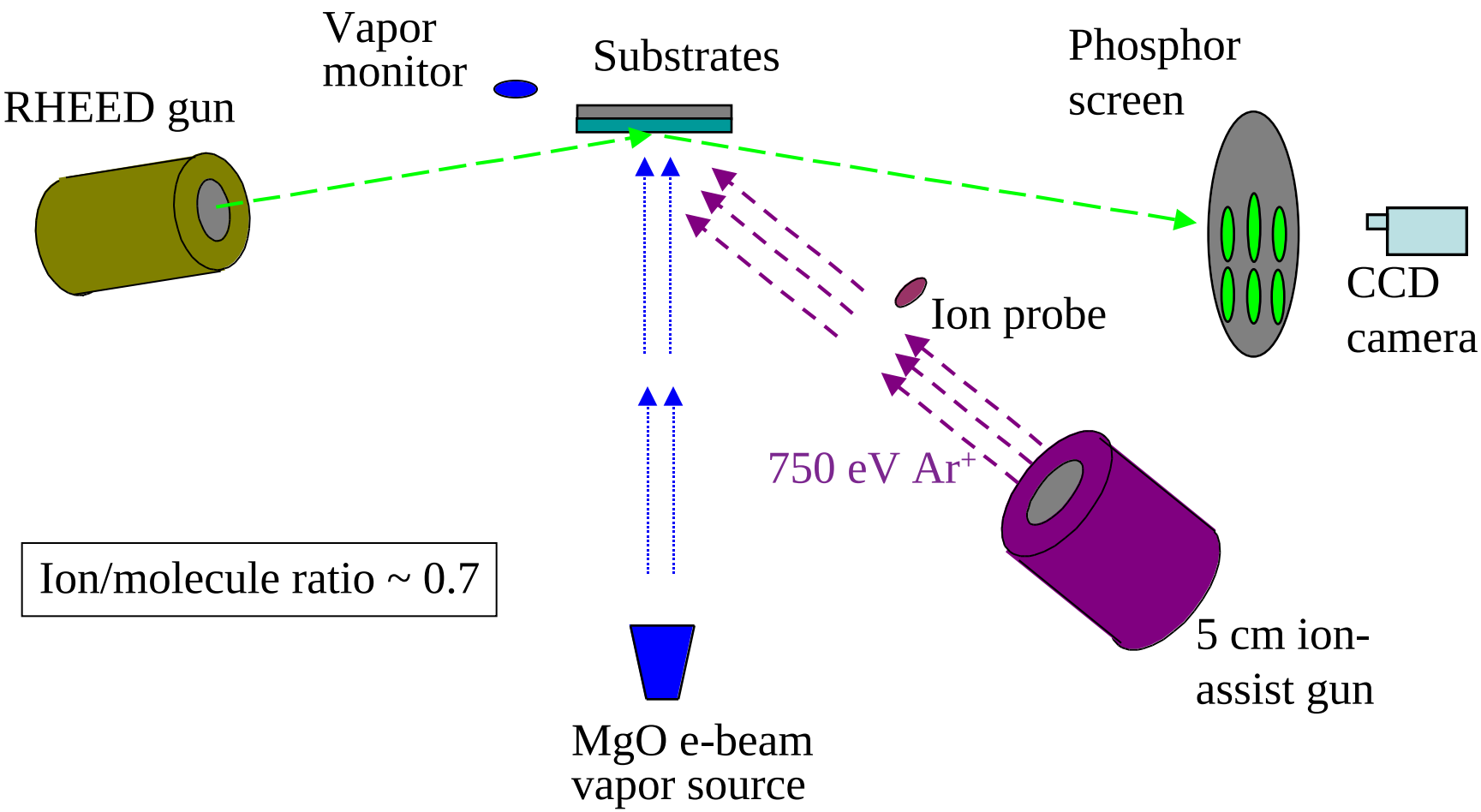
Why use IBAD MgO?



In-plane texture improvement is observed for YBCO films deposited on IBAD templates

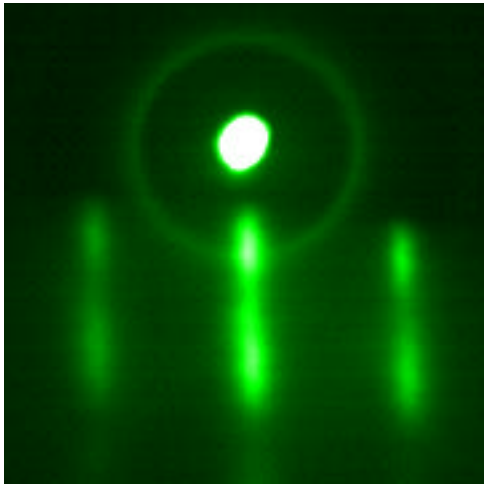


MgO research chamber schematic



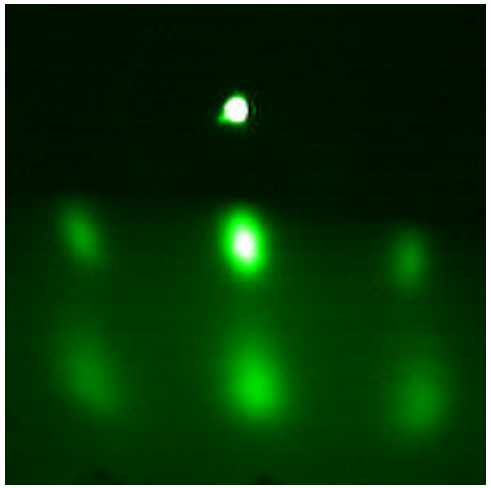
IBAD MgO film growth can be monitored for "quality" during deposition

homoepi MgO/SXAL MgO



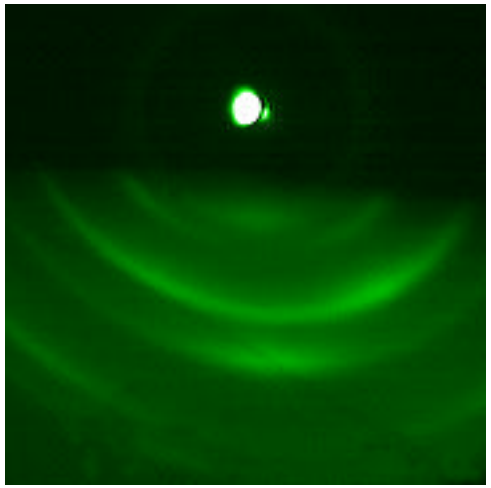
Rod-like

IBAD MgO/a-Si_3N_4/Si



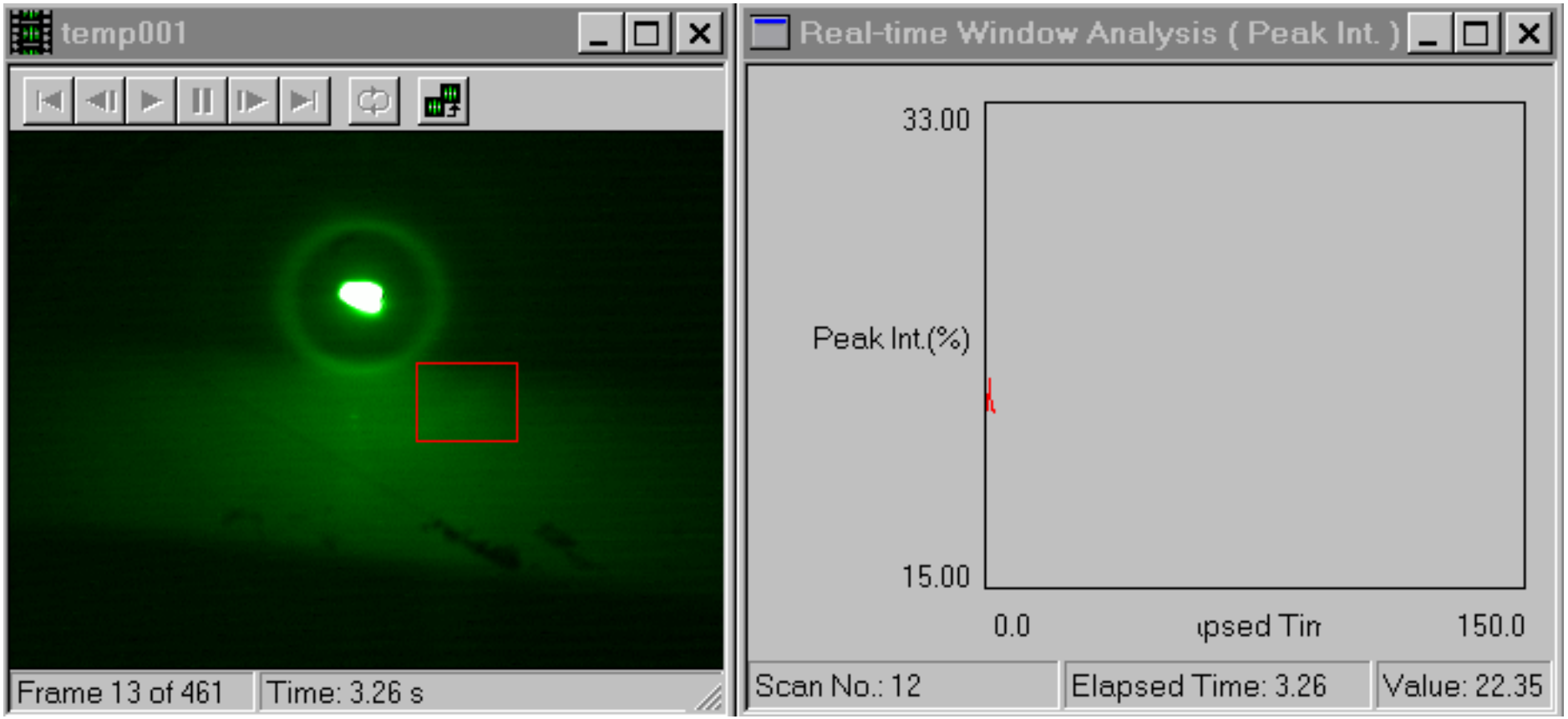
Spot-like

e-beam evaporated MgO without ion assist



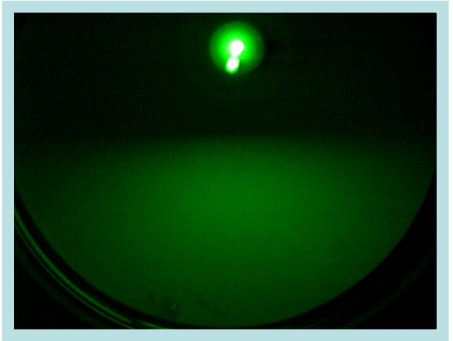
Ring-like

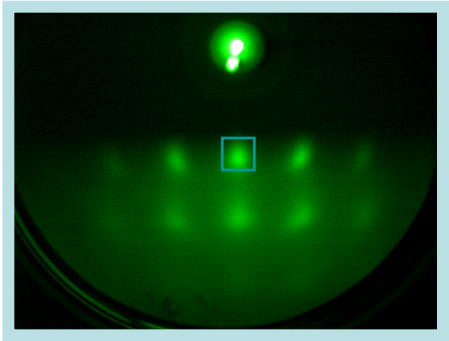
Spot intensity vs. time can be used to monitor growth of IBAD

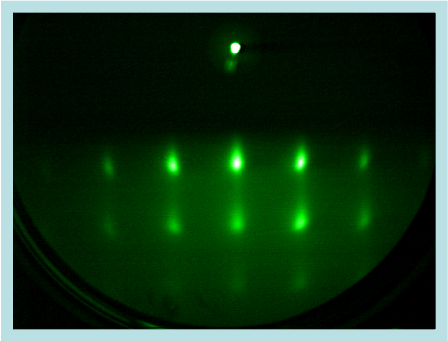


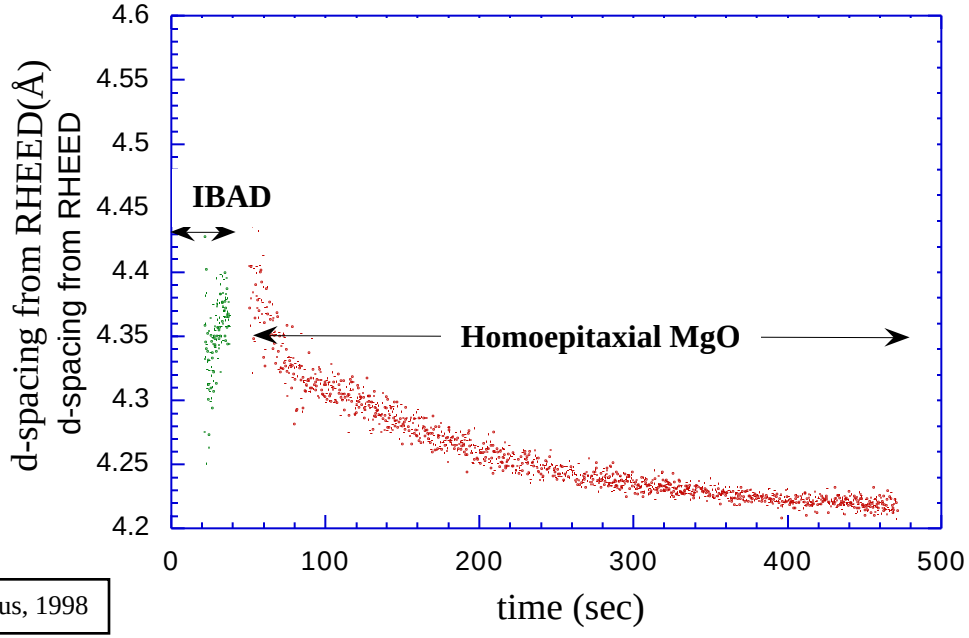
RHEED pattern evolution during growth of MgO*

a-Si_3N_4 substrate | **after IBAD MgO** | **after homoepi MgO**



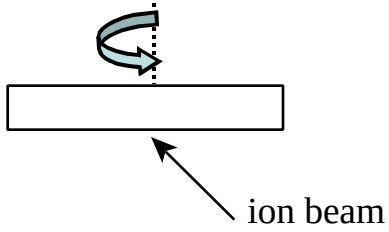




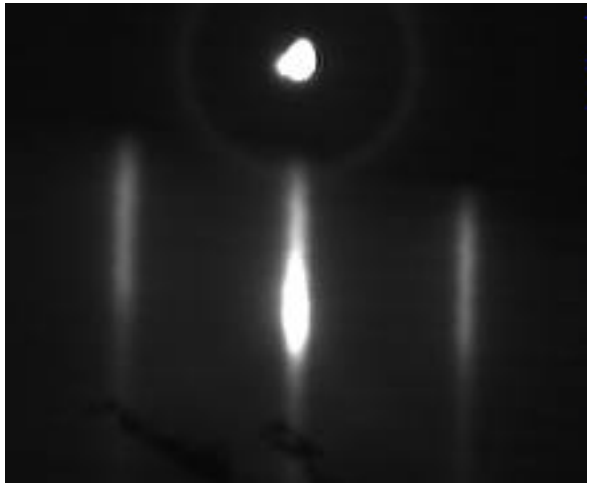


*V. Matijasevic, Conductus, 1998

Tilting observed of spot patterns when sample was rotated 90° with-respect-to direction of ion-assist beam

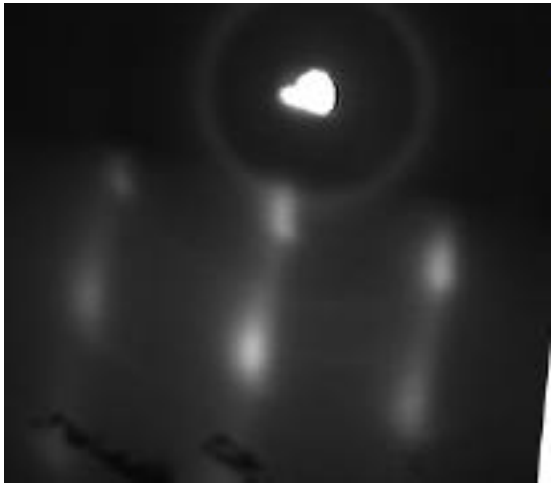


100 Å

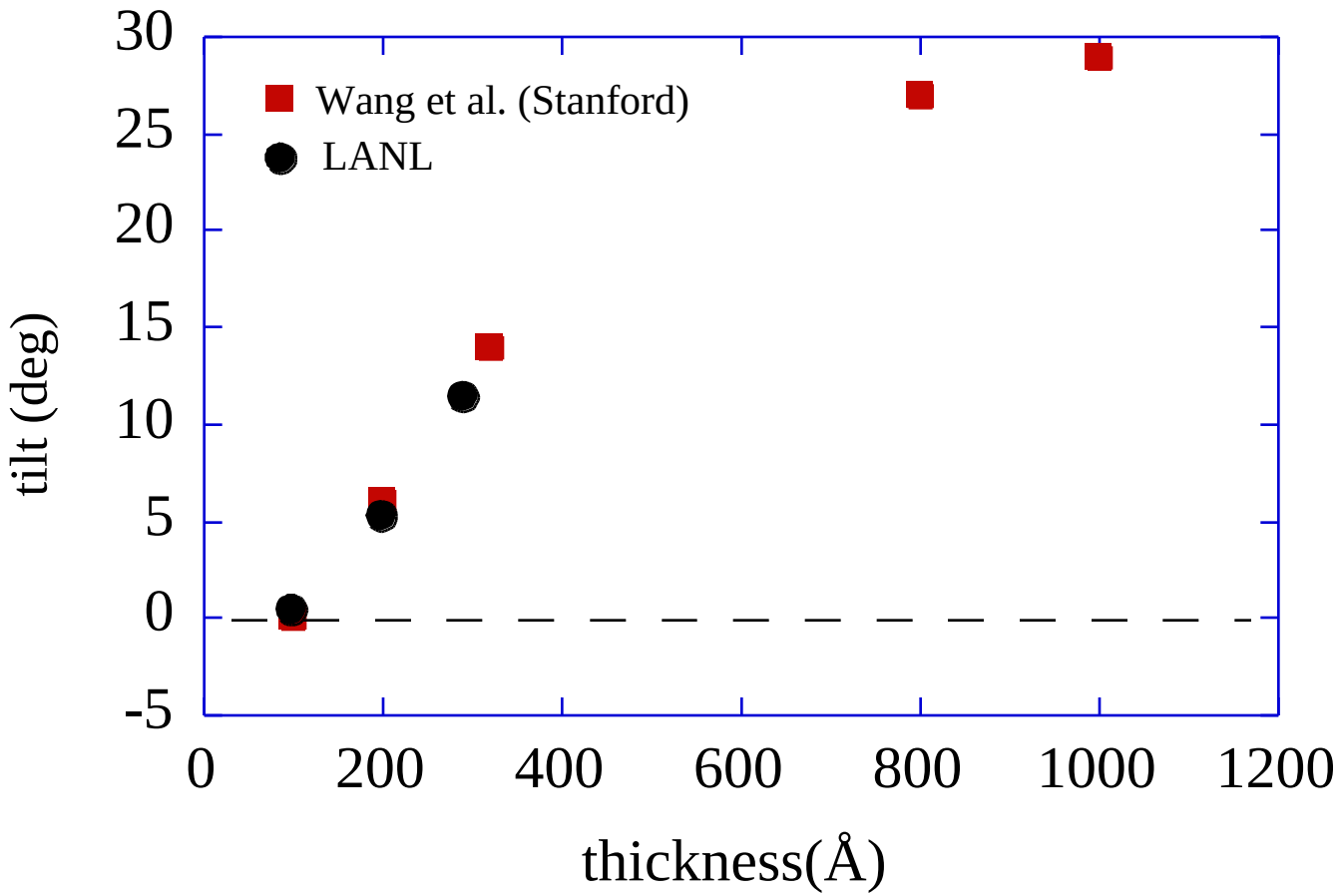


200 Å

300 Å

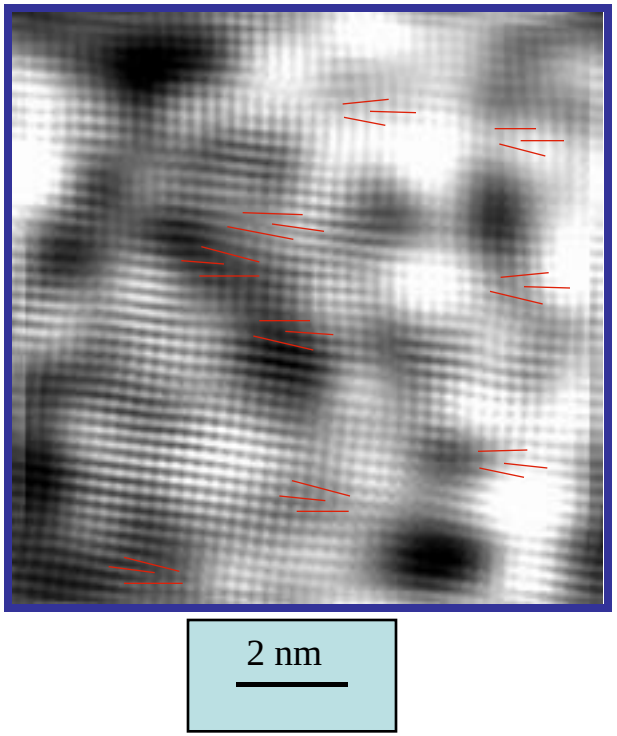


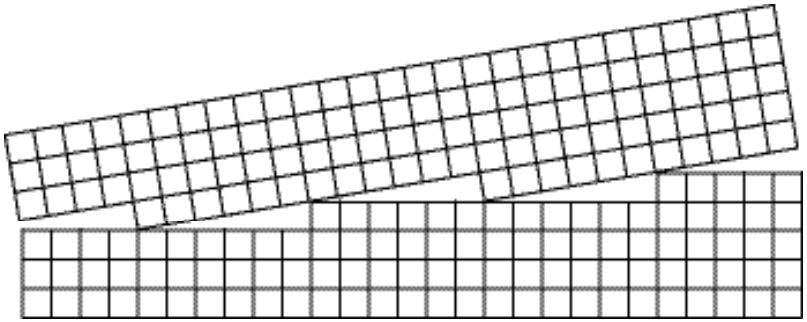
Lattice tilting continues with increasing IBAD thickness

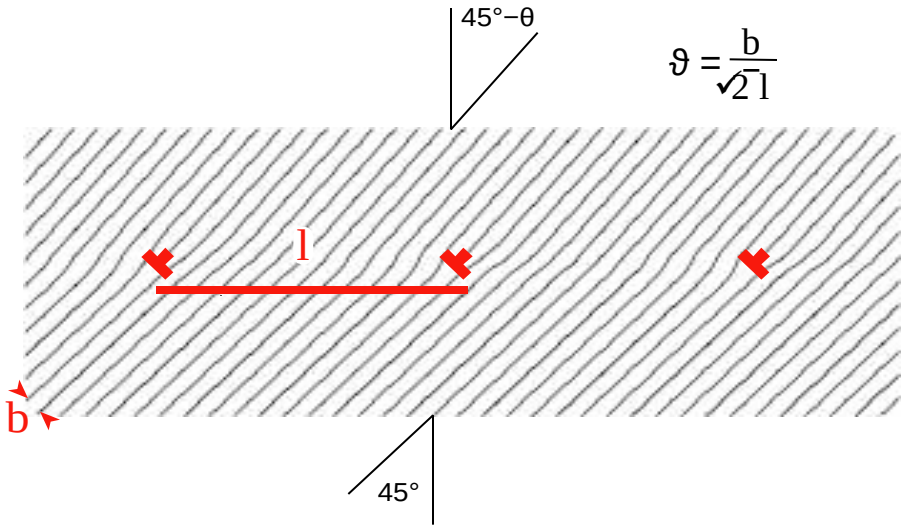


Radiation-induced dislocations in IBAD MgO provide a mechanism for lattice tilting

Interstitial point defects coalesce to form {110} type planes

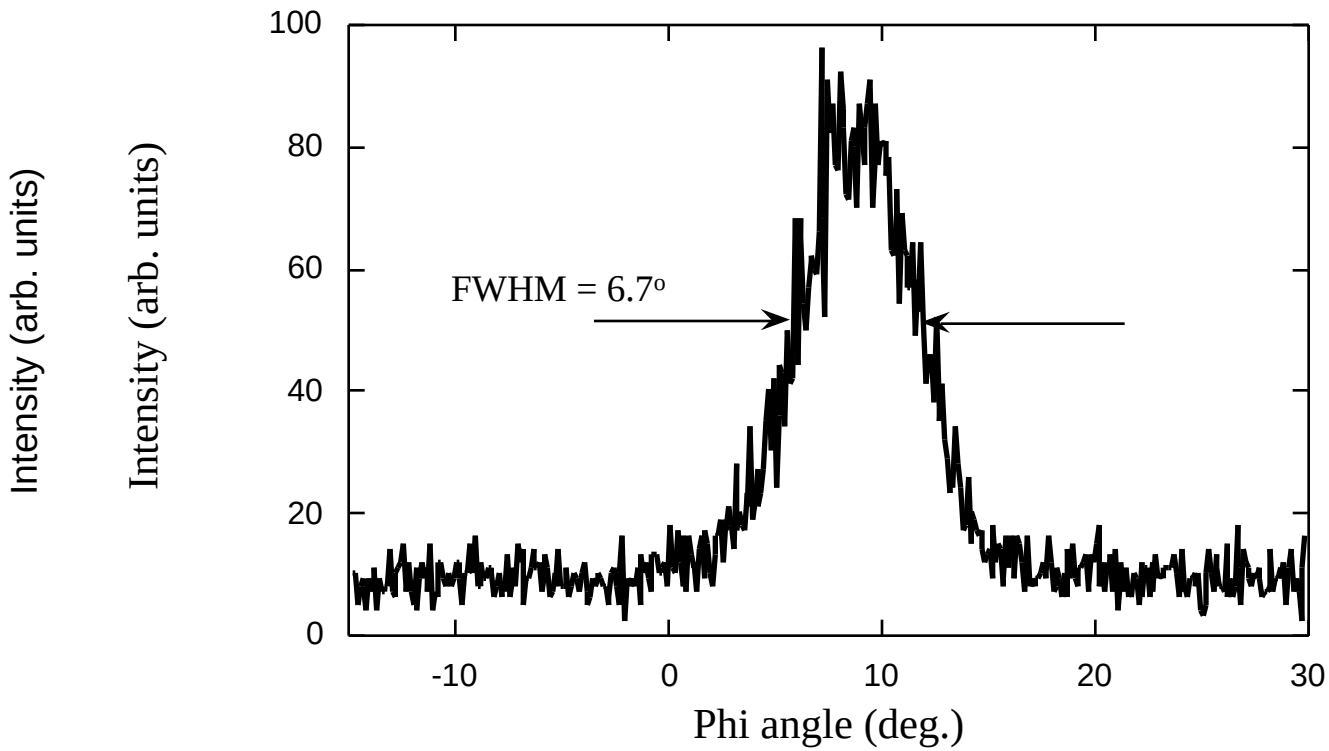






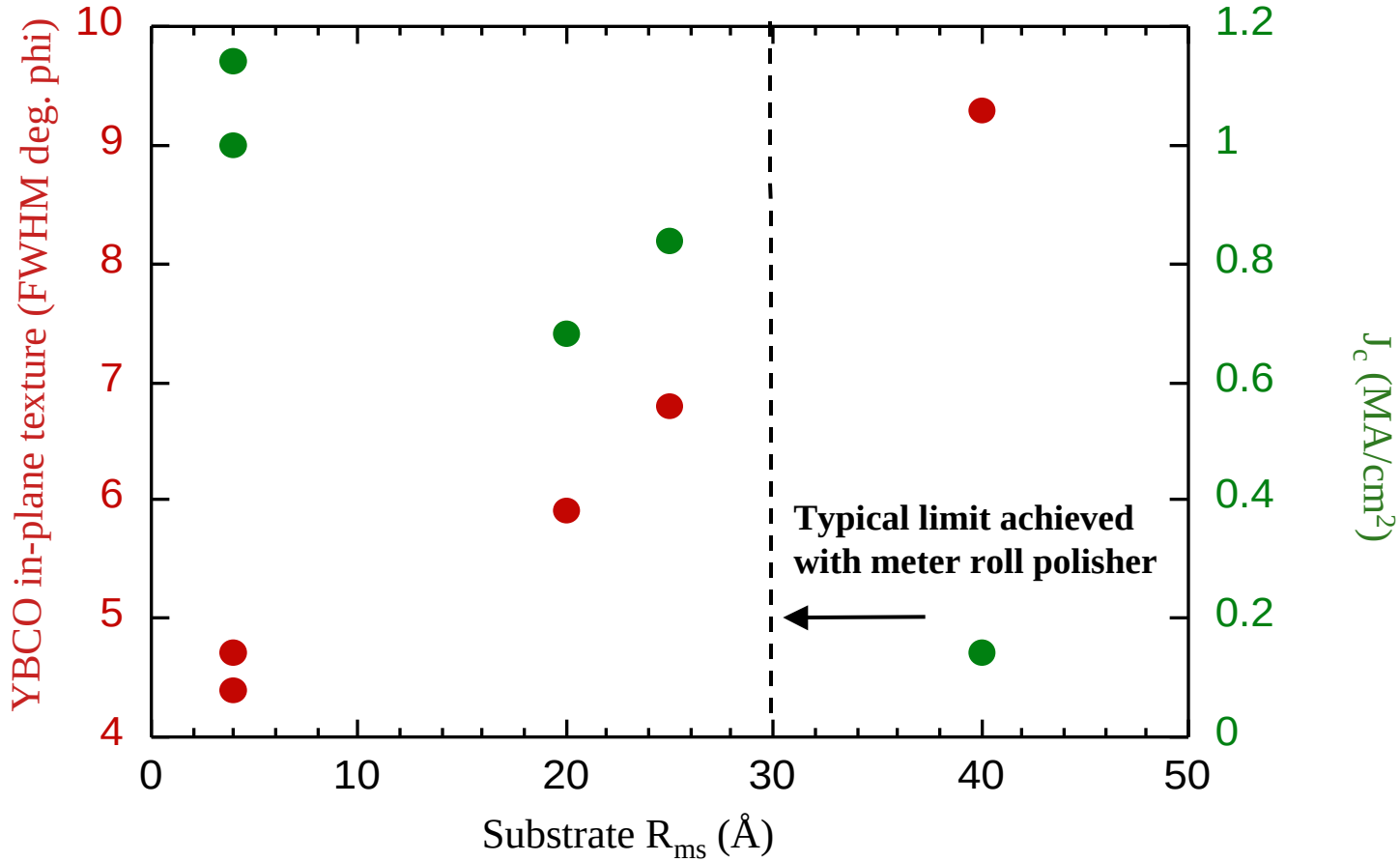
~ 10^{12} dislocations/cm^2 in 200 Å allows a 5° tilt

Calibration of RHEED I vs. t curve with XRD results allowed for optimization of IBAD MgO in-plane texture



homoepi-MgO/IBAD MgO/ a-Si_3N_4/bp-C276

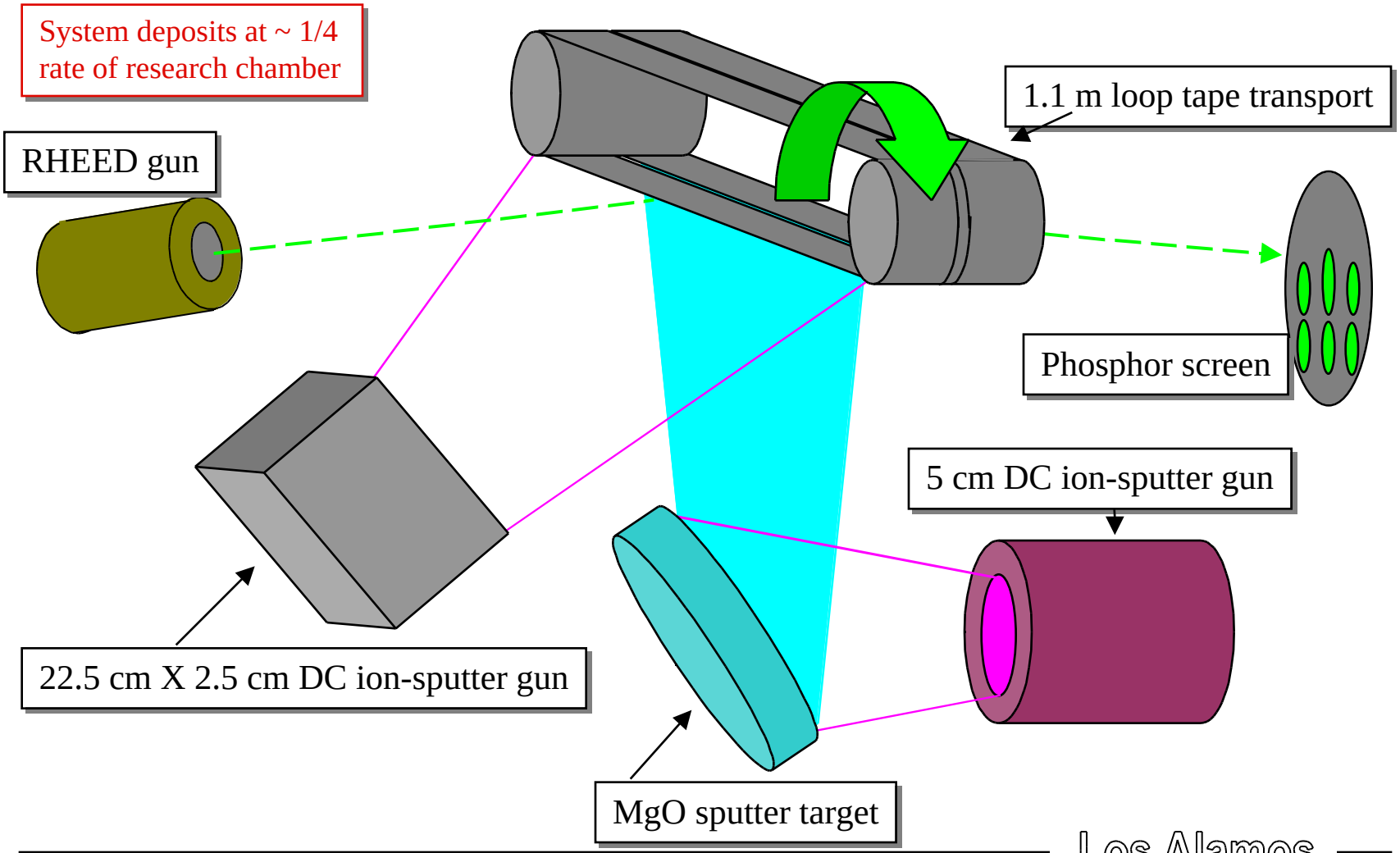
Substrate roughness must be minimized to optimize YBCO/IBAD MgO texture



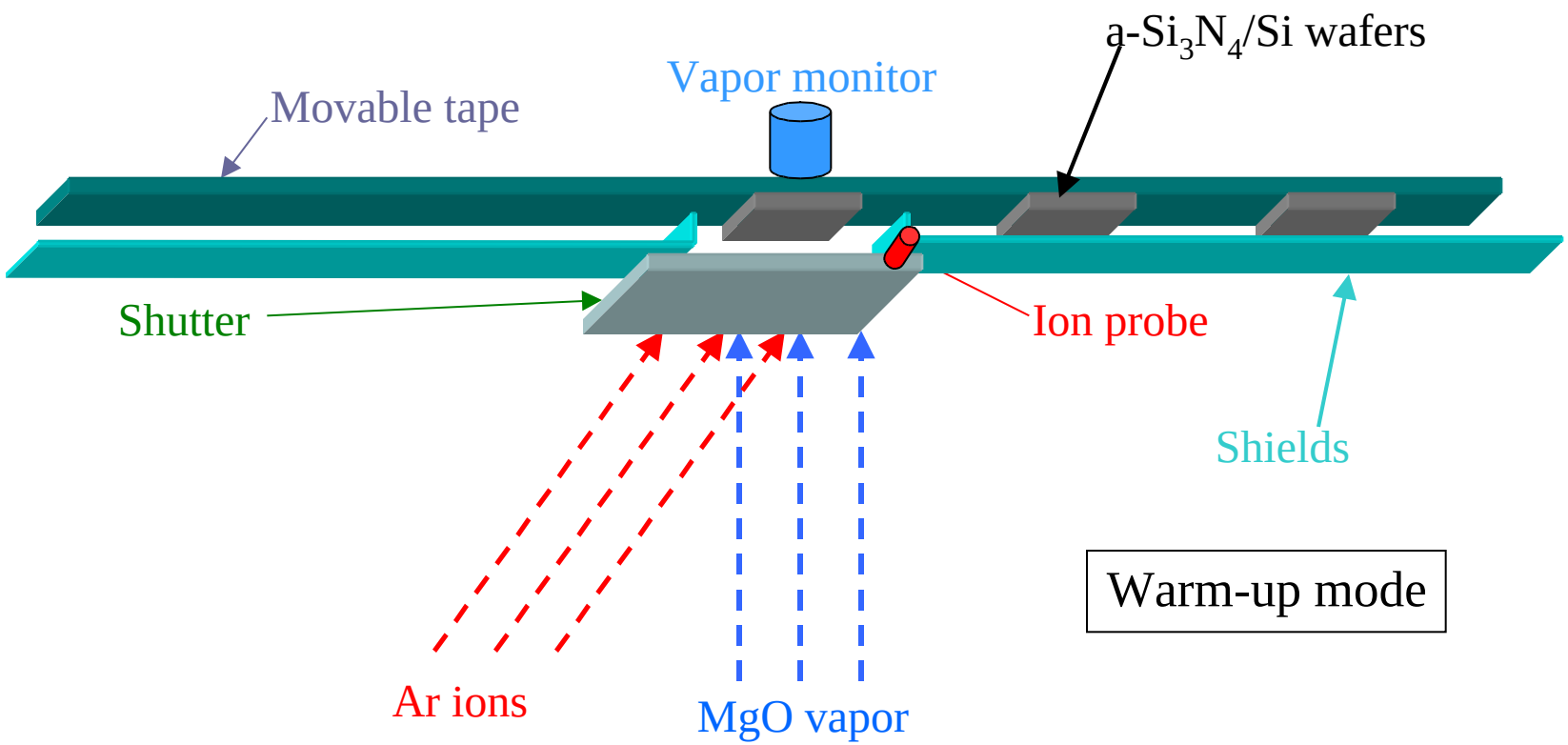
***5 x 5 μm AFM scan area**

YBCO/CeO_2/YSZ/h-MgO/IBAD MgO/ a-Si_3N_4/bp-C276

Transfer of batch process parameters to loop coating system

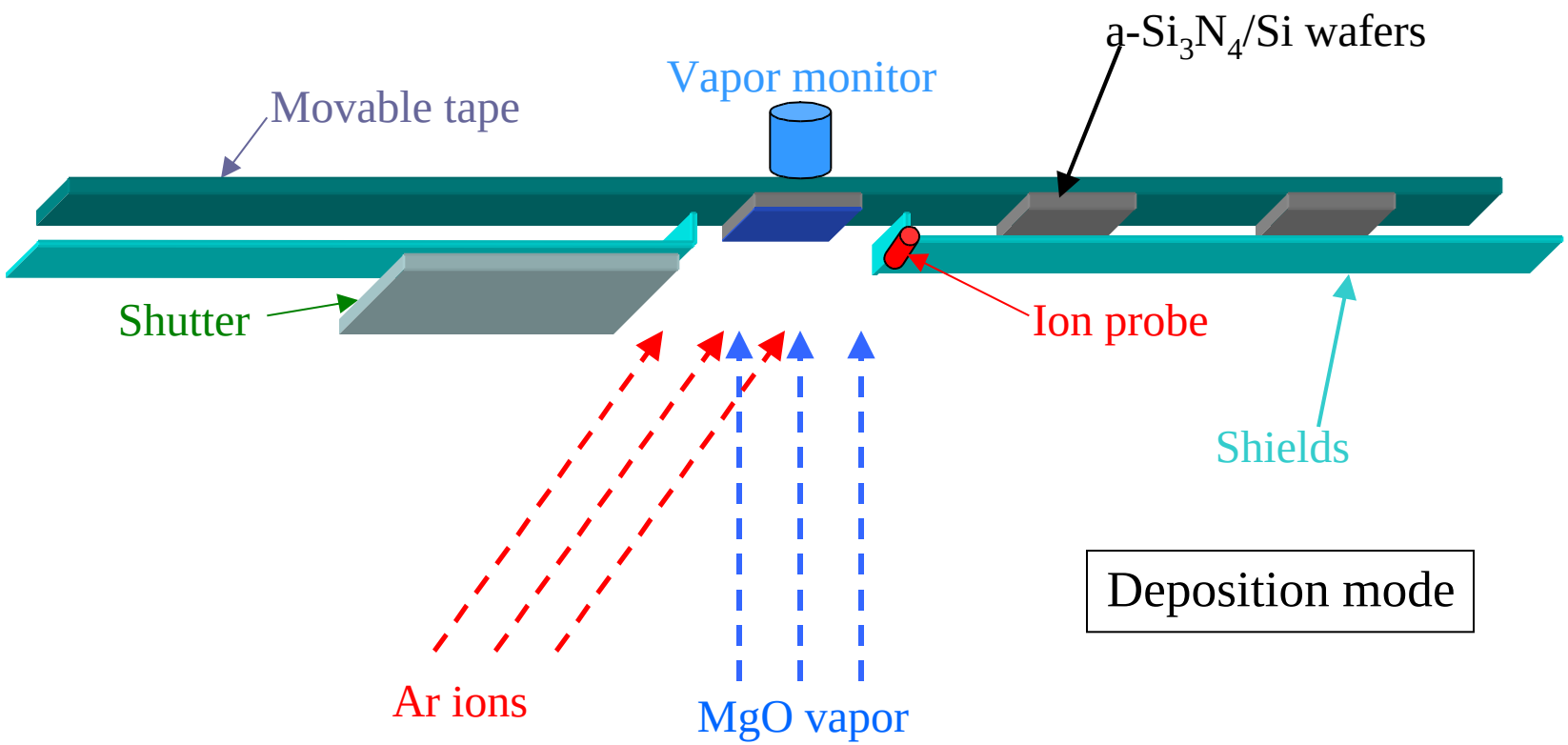


Several experiments to optimize deposition parameters may be performed in one pump down

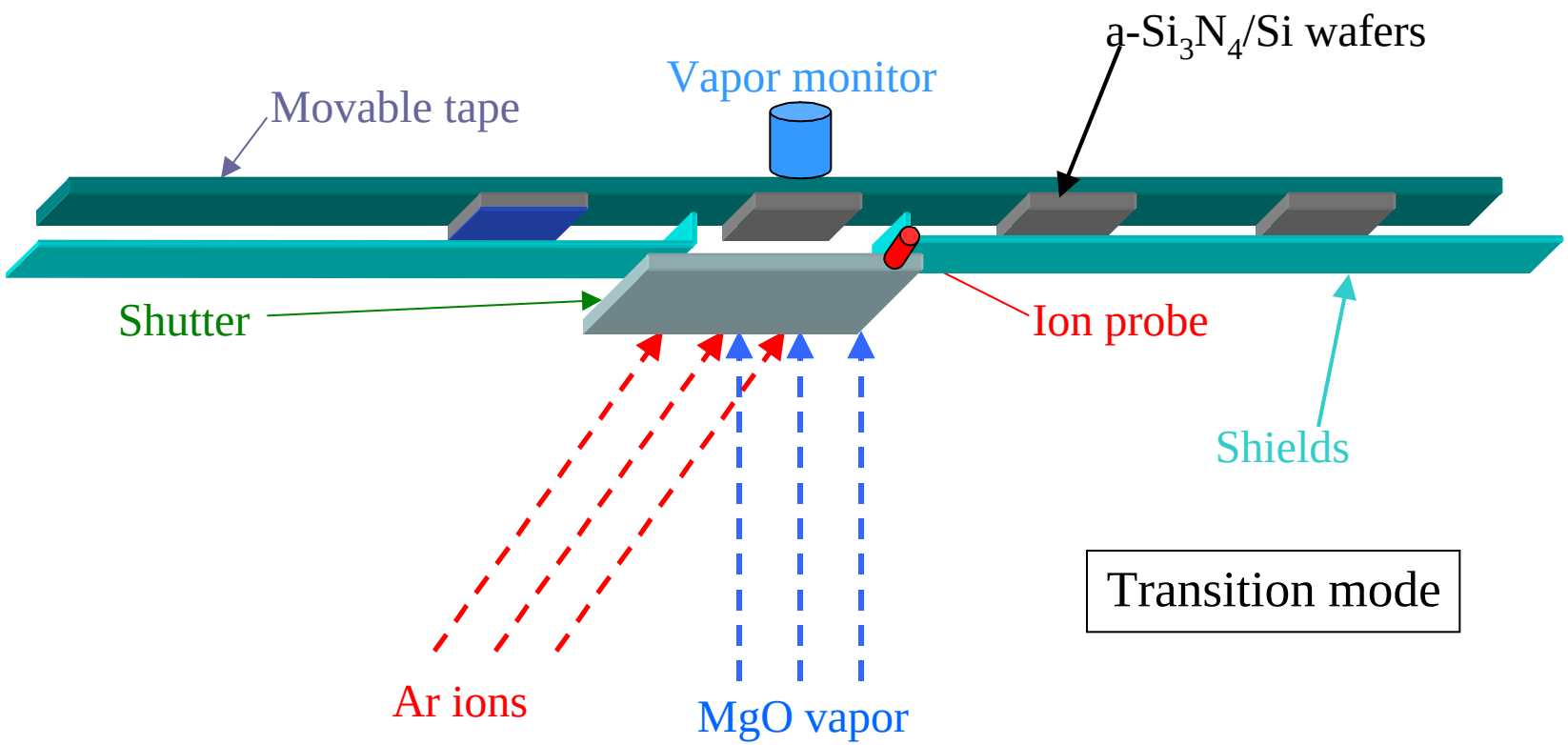


Warm-up mode

Several experiments to optimize deposition parameters may be performed in one pump down

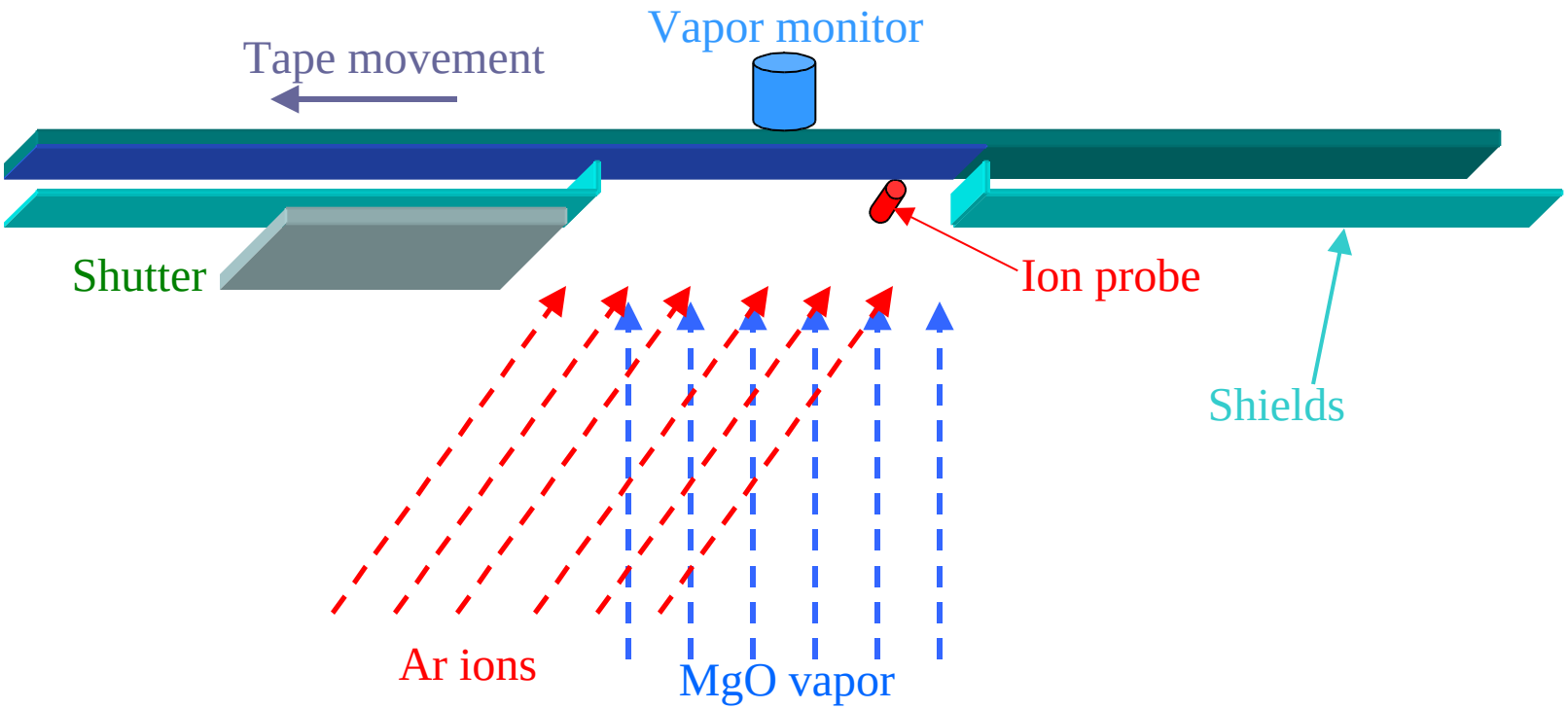


New substrate is brought into position and deposition parameters are changed

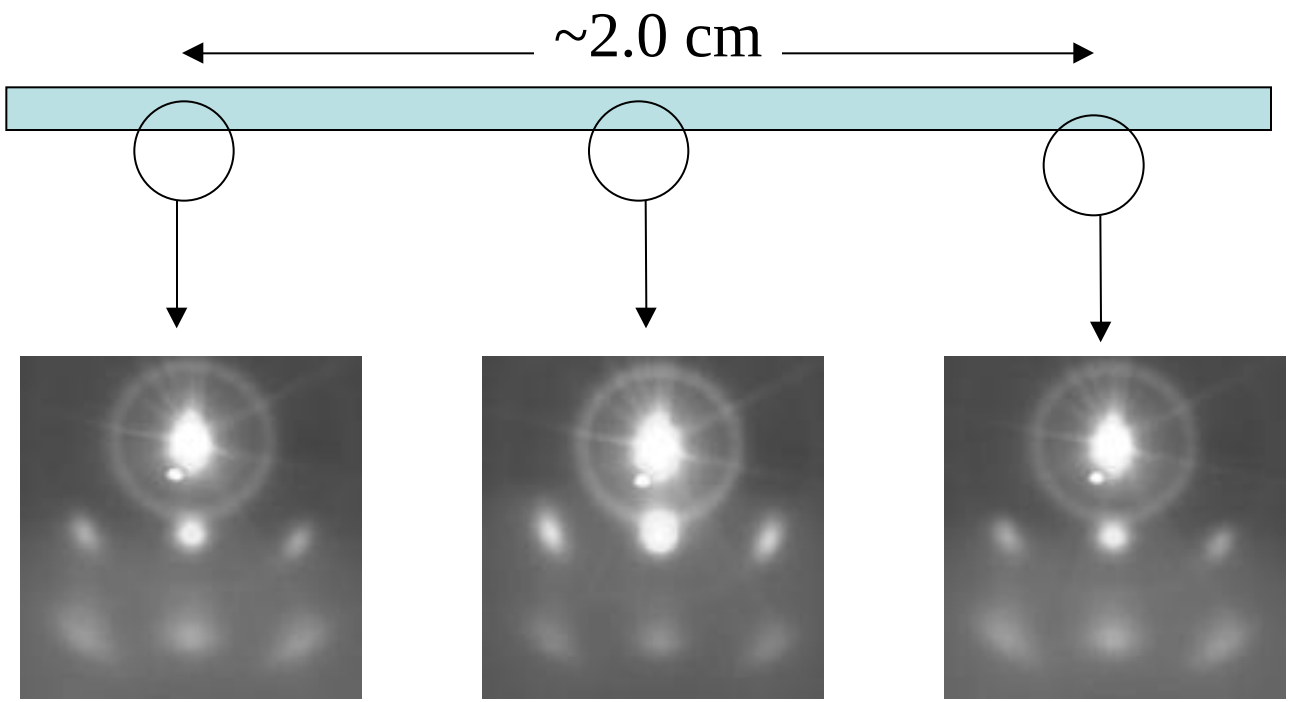


Transition mode

Tape coating mode - shields separated further to accommodate wider deposition zone



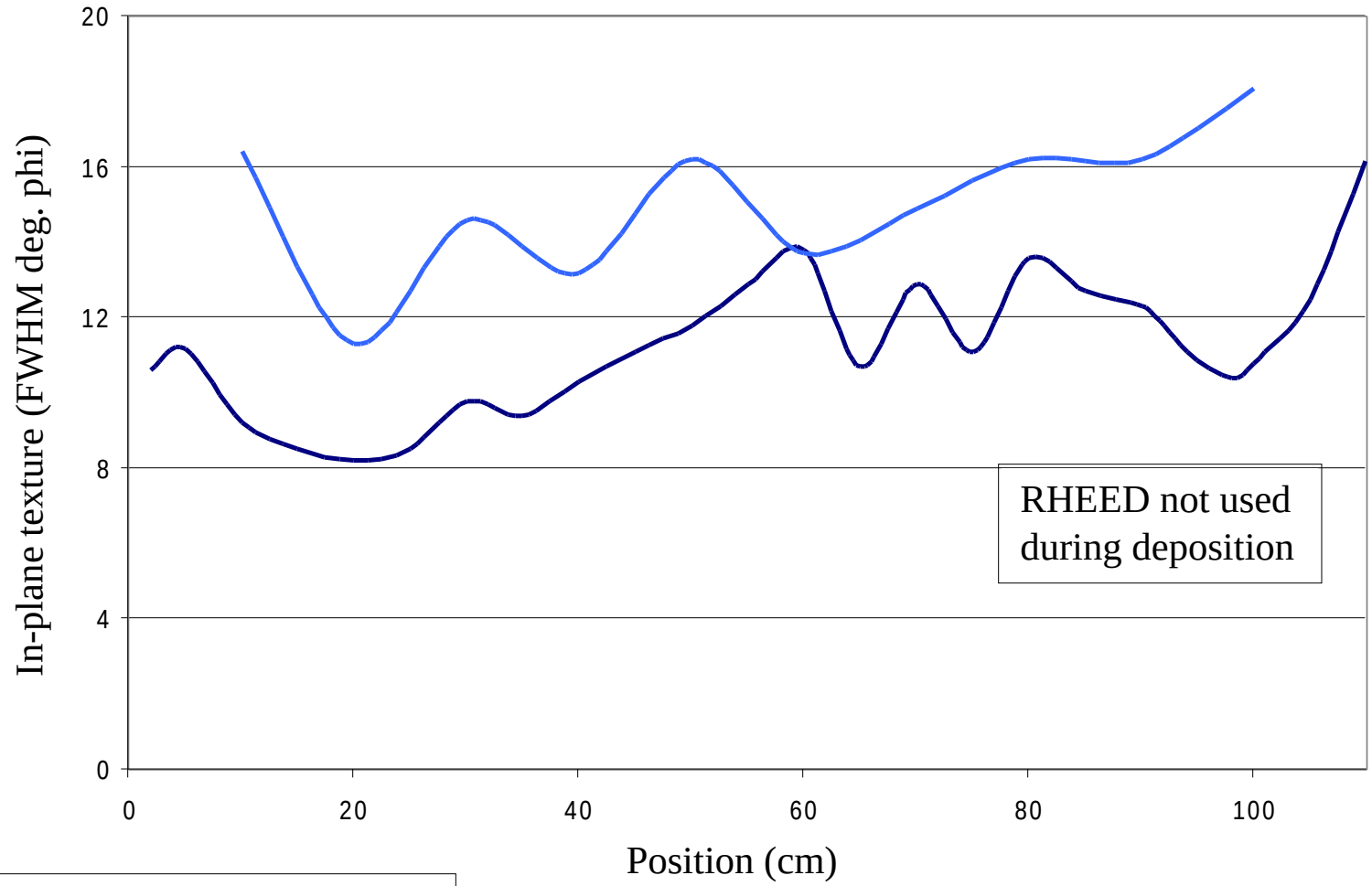
RHEED images may be obtained during continuous processing of tape



Beam sweep less than width of deposition window (~10 cm)

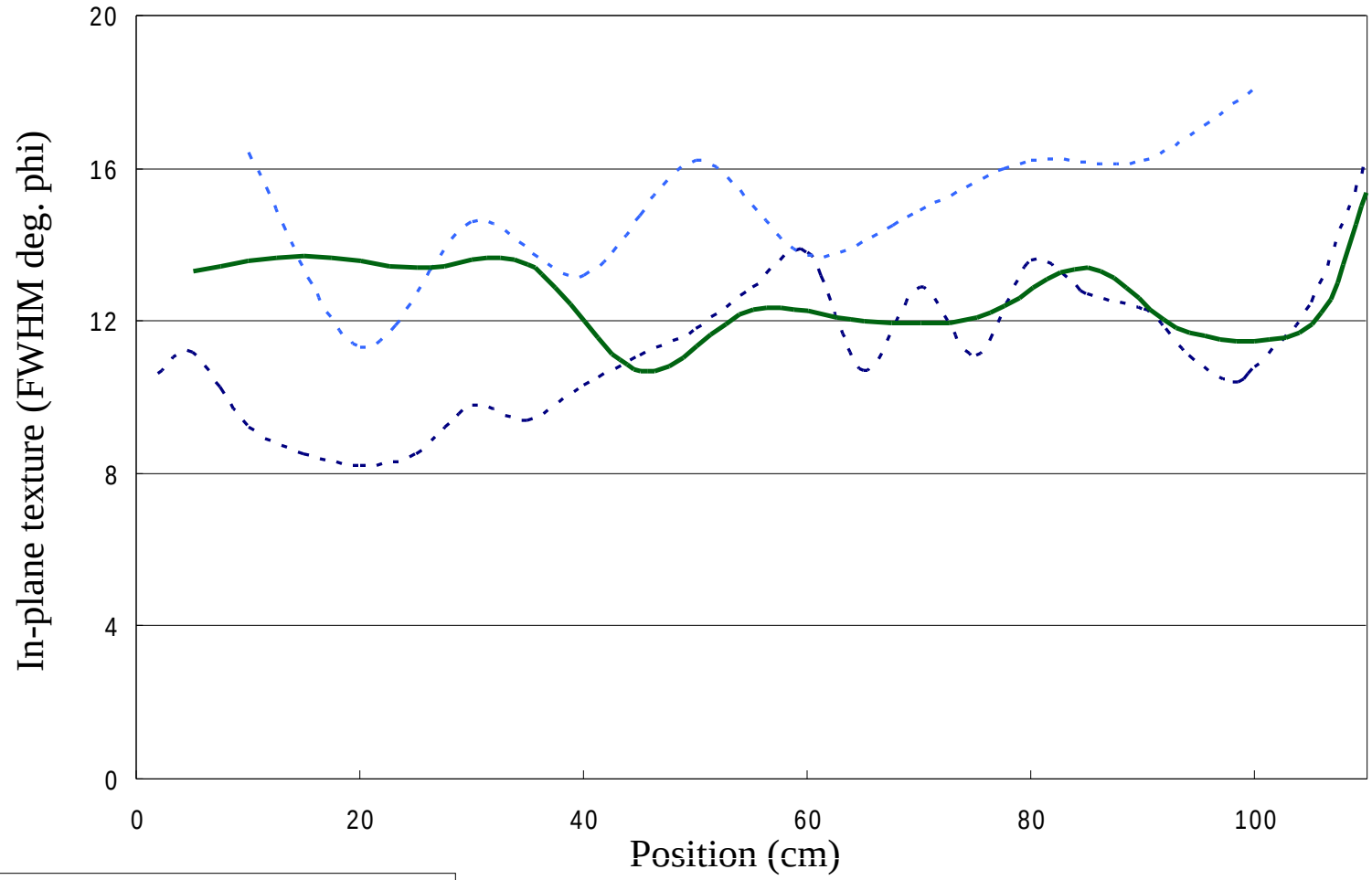
Tape movement causes RHEED pattern fluctuations

IBAD MgO texture variations of first two continuously processed tapes



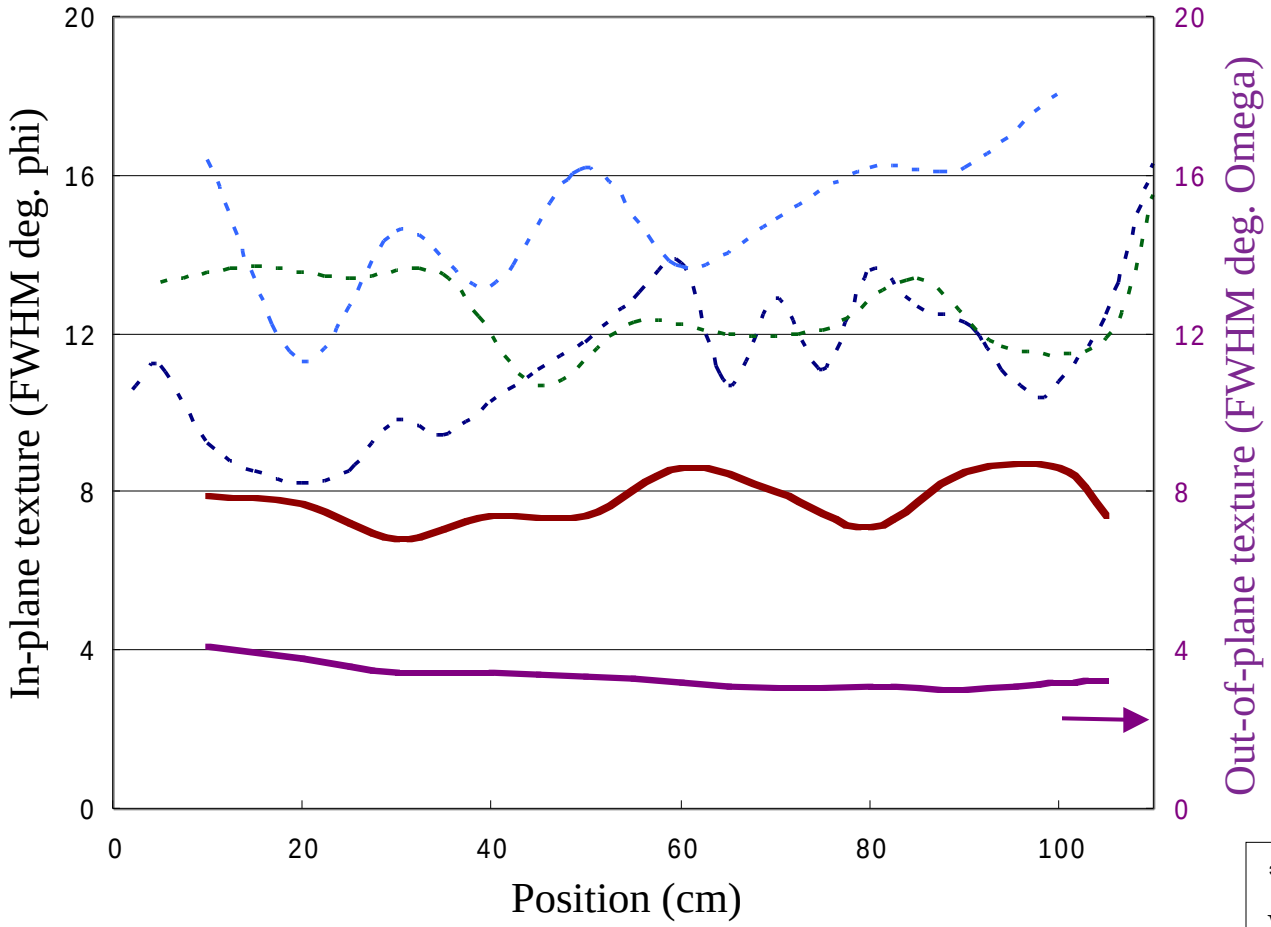
homoepi-MgO/IBAD MgO/ a-Si_3N_4/rp-I625

IBAD MgO texture variations improved using two passes through the deposition zone



homoepi-MgO/IBAD MgO/ a-Si_3N_4/rp-I625

After further refinements meter-long IBAD MgO/I-625 tapes exhibited improved texture uniformity and repeatability*



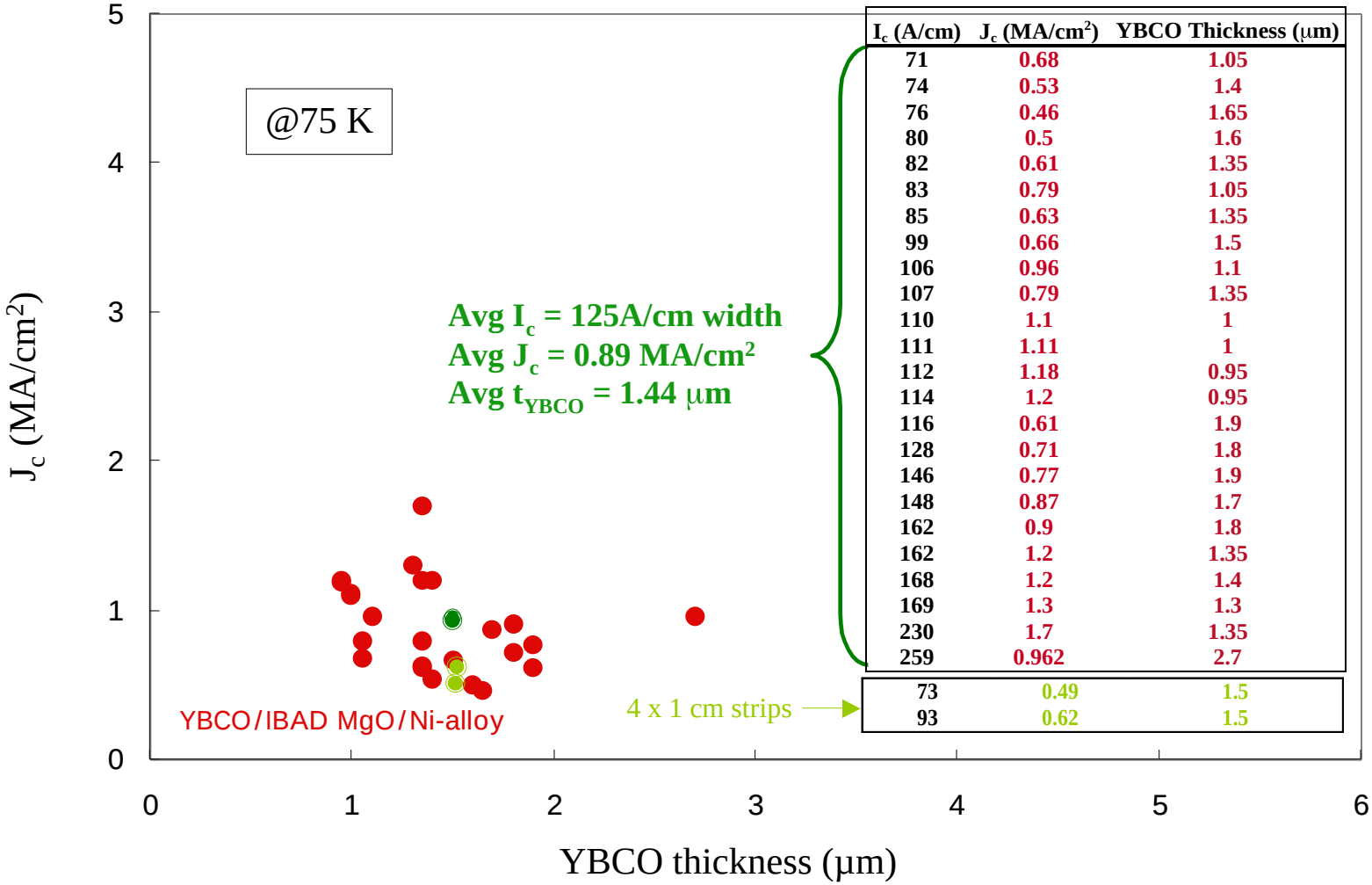
Avg. ΔΦ of most recent meters

9.8
8.1
7.8
9.3
9.2
7.8
8.6
9.3

*Ion and vapor fluences held within ± 2 % of "optimum"

homoepi-MgO/IBAD MgO/ a-Si_3N_4/rp-I625

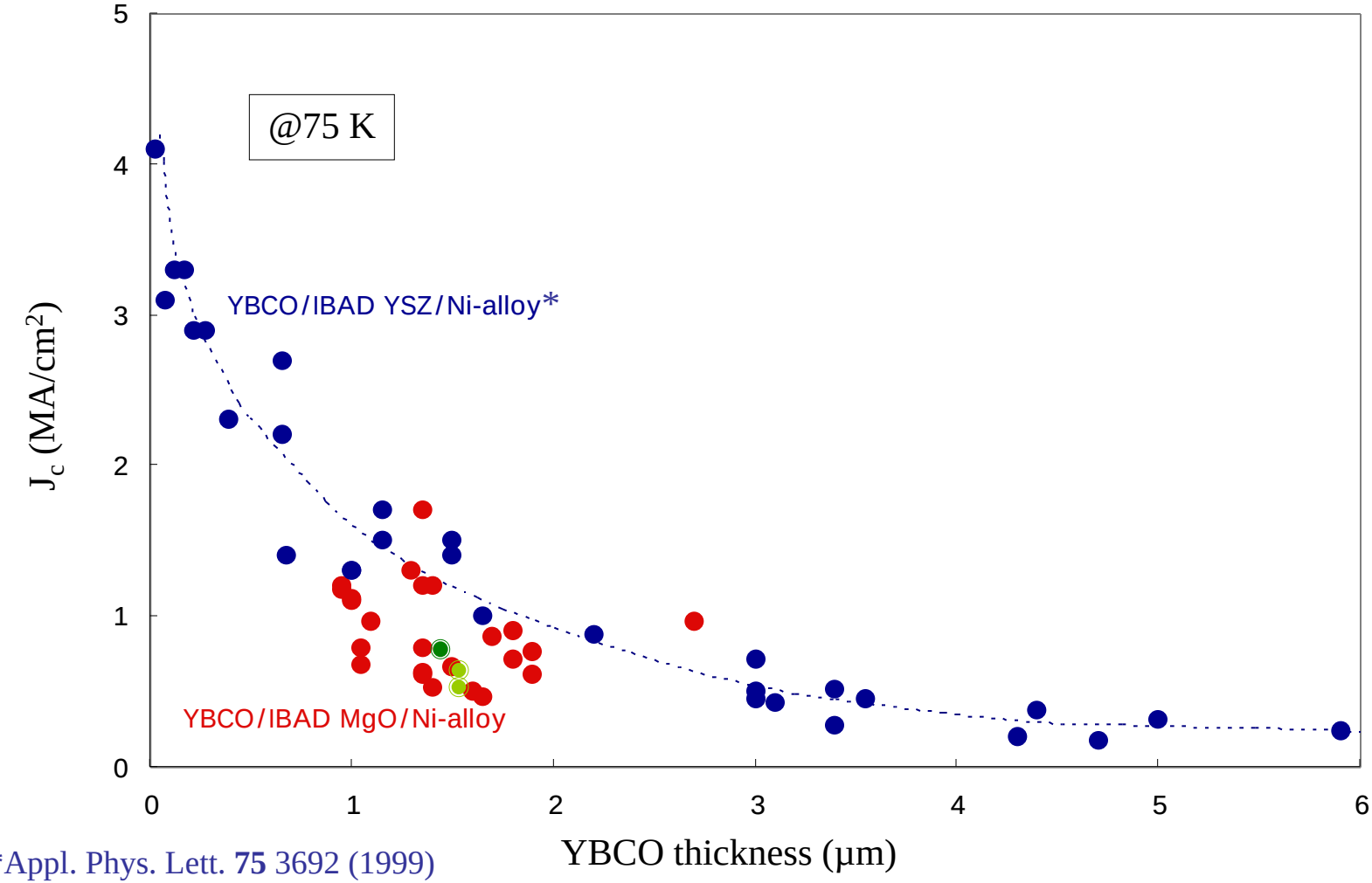
Our last 24 YBCO microbridges on a continuously processed IBAD MgO meter showed good I_c and J_c performance



I_c (A/cm)	J_c (MA/cm^2)	YBCO Thickness (μm)
71	0.68	1.05
74	0.53	1.4
76	0.46	1.65
80	0.5	1.6
82	0.61	1.35
83	0.79	1.05
85	0.63	1.35
99	0.66	1.5
106	0.96	1.1
107	0.79	1.35
110	1.1	1
111	1.11	1
112	1.18	0.95
114	1.2	0.95
116	0.61	1.9
128	0.71	1.8
146	0.77	1.9
148	0.87	1.7
162	0.9	1.8
162	1.2	1.35
168	1.2	1.4
169	1.3	1.3
230	1.7	1.35
259	0.962	2.7
73	0.49	1.5
93	0.62	1.5

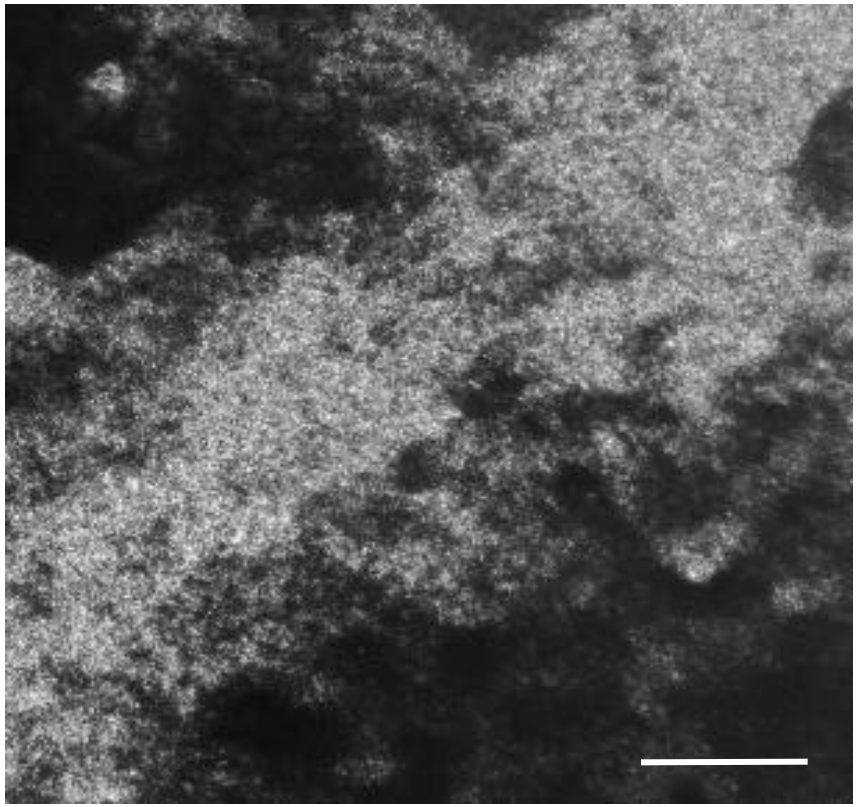
YBCO/CeO_2/YSZ/h-MgO/IBAD MgO/ a-Si_3N_4/rp-C276

J_c performance comparison of YBCO microbridges on continuously processed IBAD YSZ and IBAD MgO templates

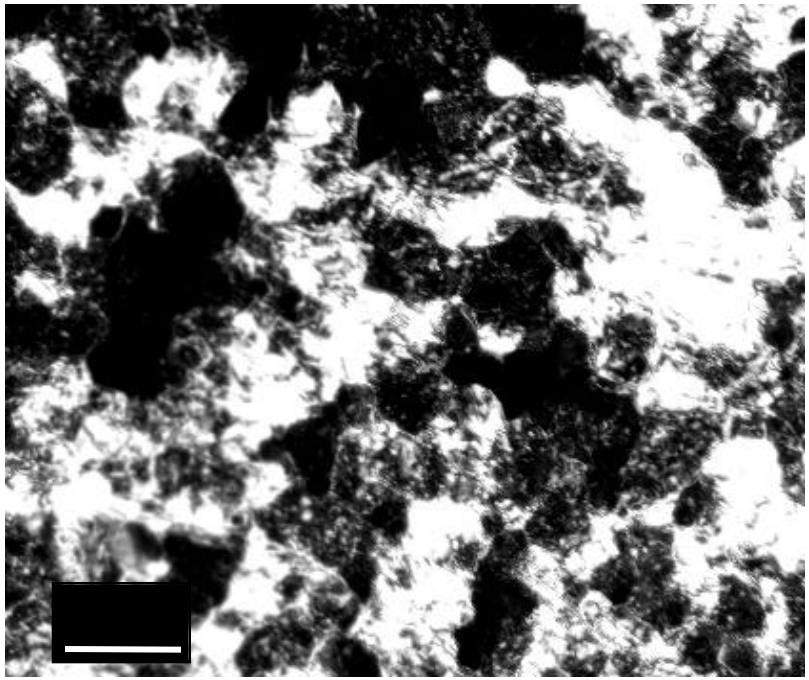


*Appl. Phys. Lett. **75** 3692 (1999)

Plan view dark field TEM reveals microstructural differences between IBAD-YSZ and IBAD-MgO



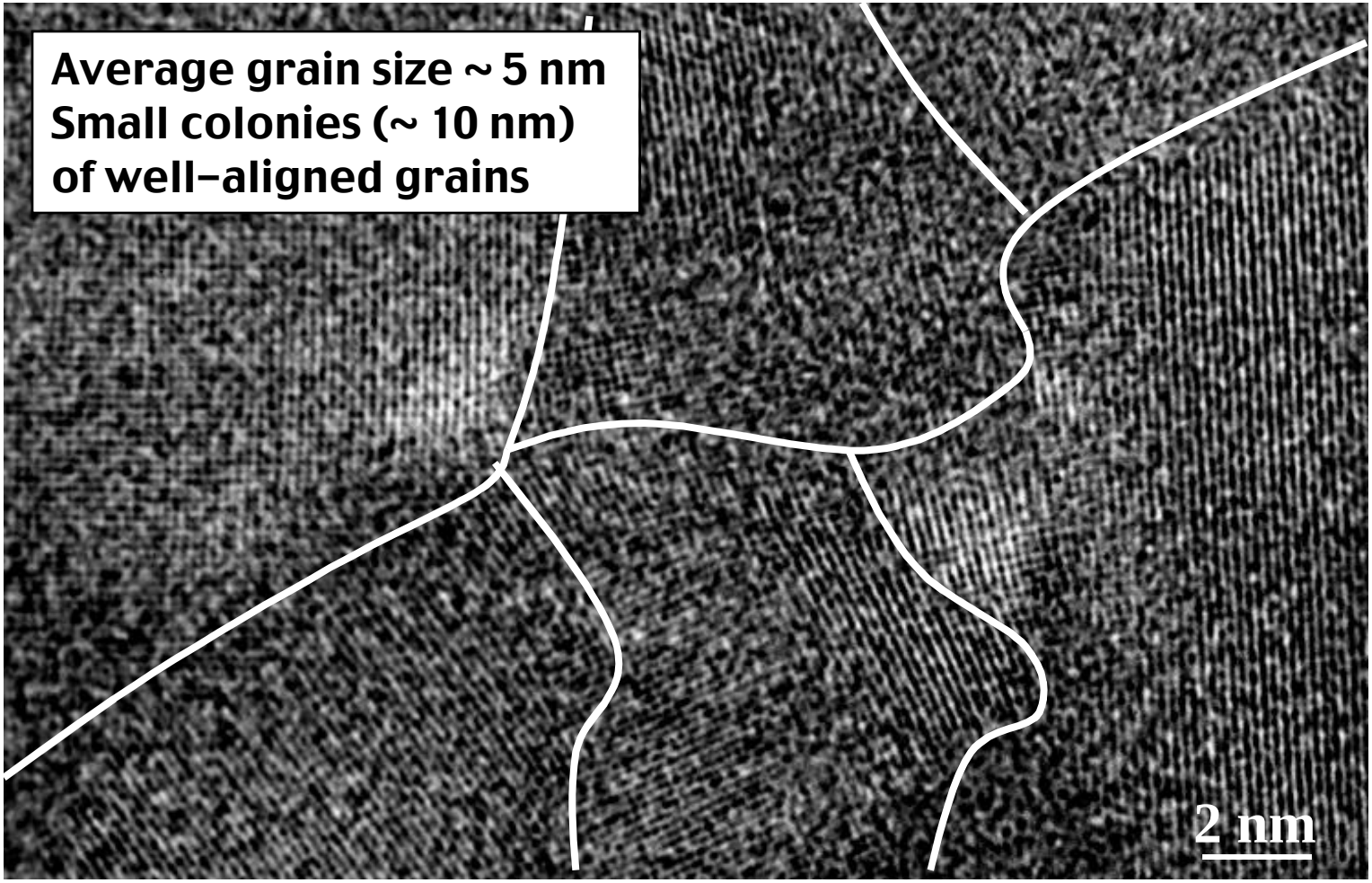
Ion-beam sputtered IBAD MgO



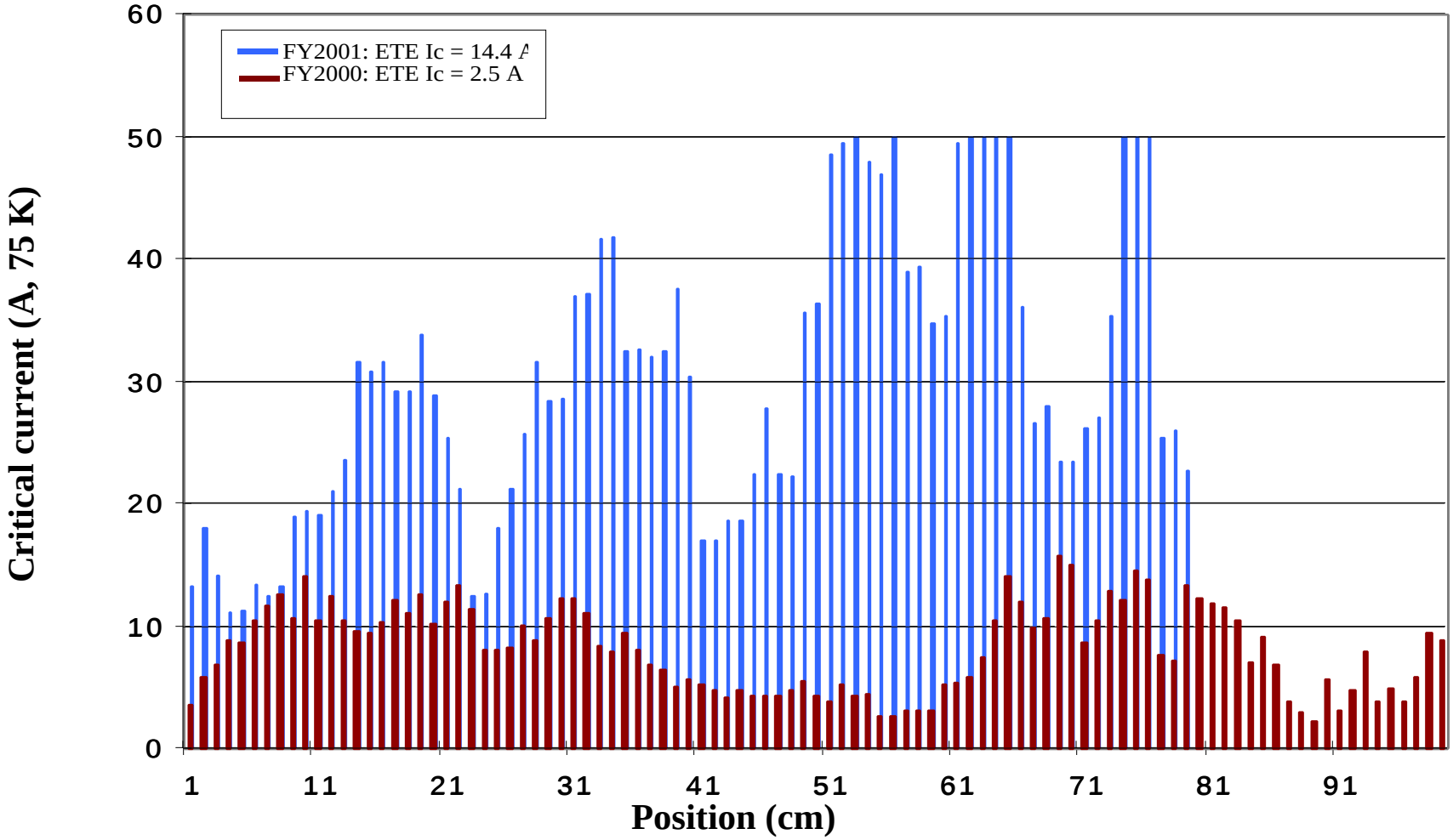
Average sub-grain size ~ 5 nm
Micron sized colony of well-aligned grains

Average grain size ~ 50 nm
Small colony (~ 200 nm) of well-aligned grains

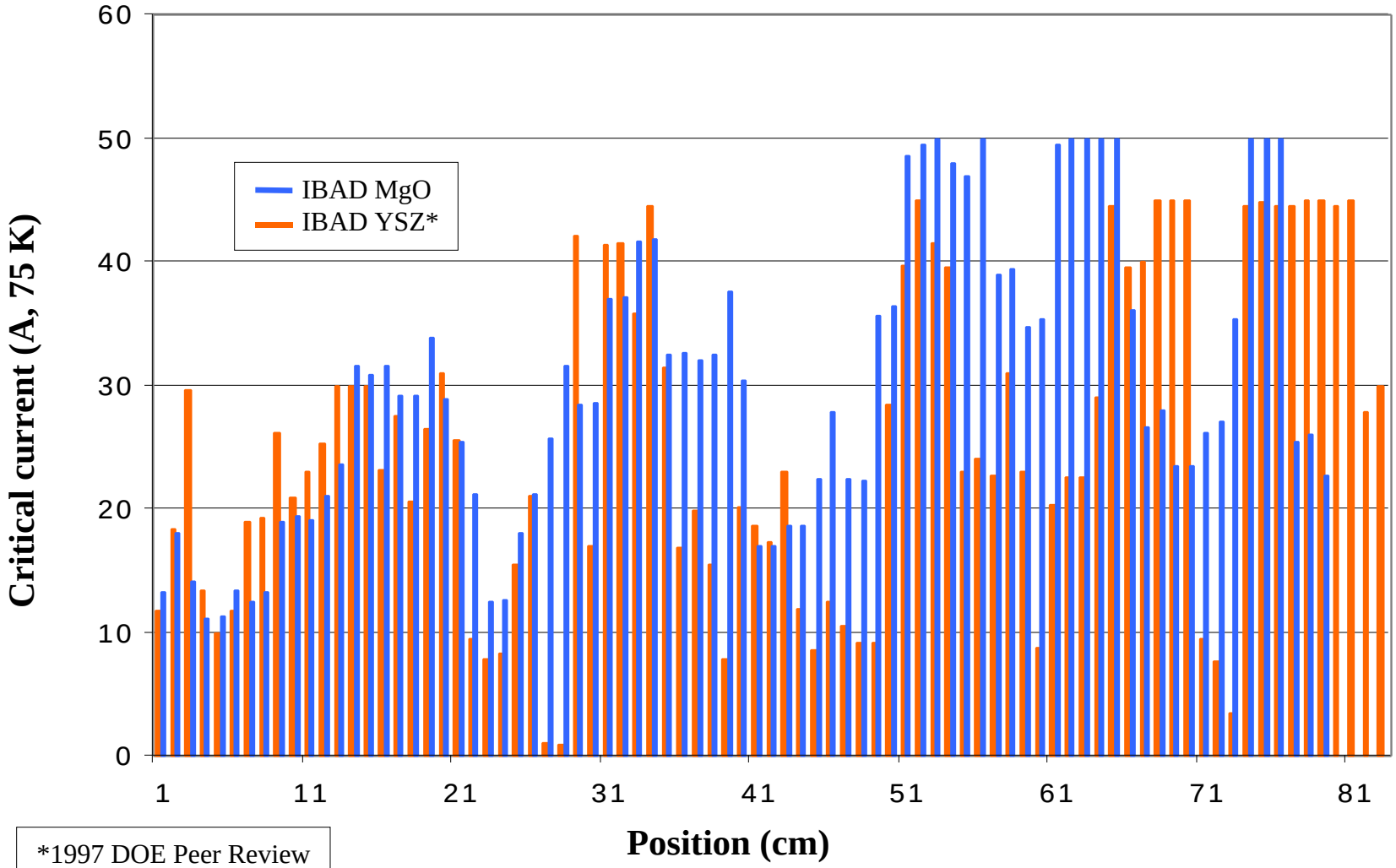
Plan view bright-field TEM reveals finer grains and smaller colony size for e-beam evaporated IBAD-MgO



I_c vs. position comparison for YBCO on IBAD MgO templates



Comparable meter length YBCO results achieved at LANL after four years of development with each template



*1997 DOE Peer Review

IBAD MgO Summary

- RHEED/x-ray diffraction used to optimize deposition parameters for IBAD MgO templates
- Demonstrated good texture on continuously processed meter lengths of IBAD MgO templates without RHEED (best: $\Delta\varphi_{ave}$ = 7.8°, $\Delta\omega_{ave}$ =3.3°)
- Demonstrated run-to-run texture repeatability with average $\Delta\varphi$~ 8.8° over meter lengths (FY2000: $\Delta\varphi_{ave}$ ~ 20°)
- Using continuously processed IBAD MgO produced: 24 bridge samples with $J_{c\text{-}aver}$(75 K) = 125 A/cm width, $J_{c\text{-}aver}$(75 K) = 0.89 MA/cm^2; 4 x 1 cm samples with best I_c(75 K) = 93 A
- Best YBCO/IBAD MgO tape result: I_c(75 K) = 14.4 A (80 cm length)

Future issues:

- Improve performance of YBCO/IBAD MgO meters to be comparable to that of YBCO/IBAD YSZ meters
- Simplify buffer layer stack
- Demonstrate < 5 minute/meter deposition time for IBAD MgO
- Investigate non-RHEED methods for optimizing IBAD MgO