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# Pure-sulfide CZTS solar cells by pulsed laser deposition

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Deposition parameters	Target	Annealed in	Device structure
<ul style="list-style-type: none"> <li>Temperature: 25°C</li> <li>Base pressure: 10<sup>-7</sup> mbar</li> <li>Laser: Excimer KrF</li> <li>248 nm, 20 ns pulse @10Hz</li> </ul>	Compound Cu <sub>2</sub> ZnSnS <sub>4</sub> (Cu/Zn = 1.8)	100 mbar N2 200 mg S 570°C 10 min	<b>Mo</b> – 600 nm - DC sputtering <b>CZTS</b> – 800 nm - pulsed laser deposition <b>CdS</b> – 70 nm - chemical bath deposition <b>ZnO/AZO</b> – 70/250 nm - RF sputtering

## ??? Why pulsed laser deposition ???

PROS	CONS
<ol style="list-style-type: none"> <li>Many tunable parameters</li> <li>Kinetic energy of ablated species promotes surface mobility at the substrate</li> <li>Non-equilibrium deposition conditions → <b>control over defect formation?</b></li> </ol>	<ol style="list-style-type: none"> <li>Complex physics</li> <li>Expensive production method</li> <li>Radially inhomogeneous flux of species</li> <li>Ejection of micro-particulate (<b>solved after annealing!</b>)</li> </ol>

## Pulsed laser deposition setup

**Laser fluence** = pulse energy / beam area  
 Pulse energy: constant over 1 hour deposition time  
 Beam area: tuned by changing the **lens-target distance**

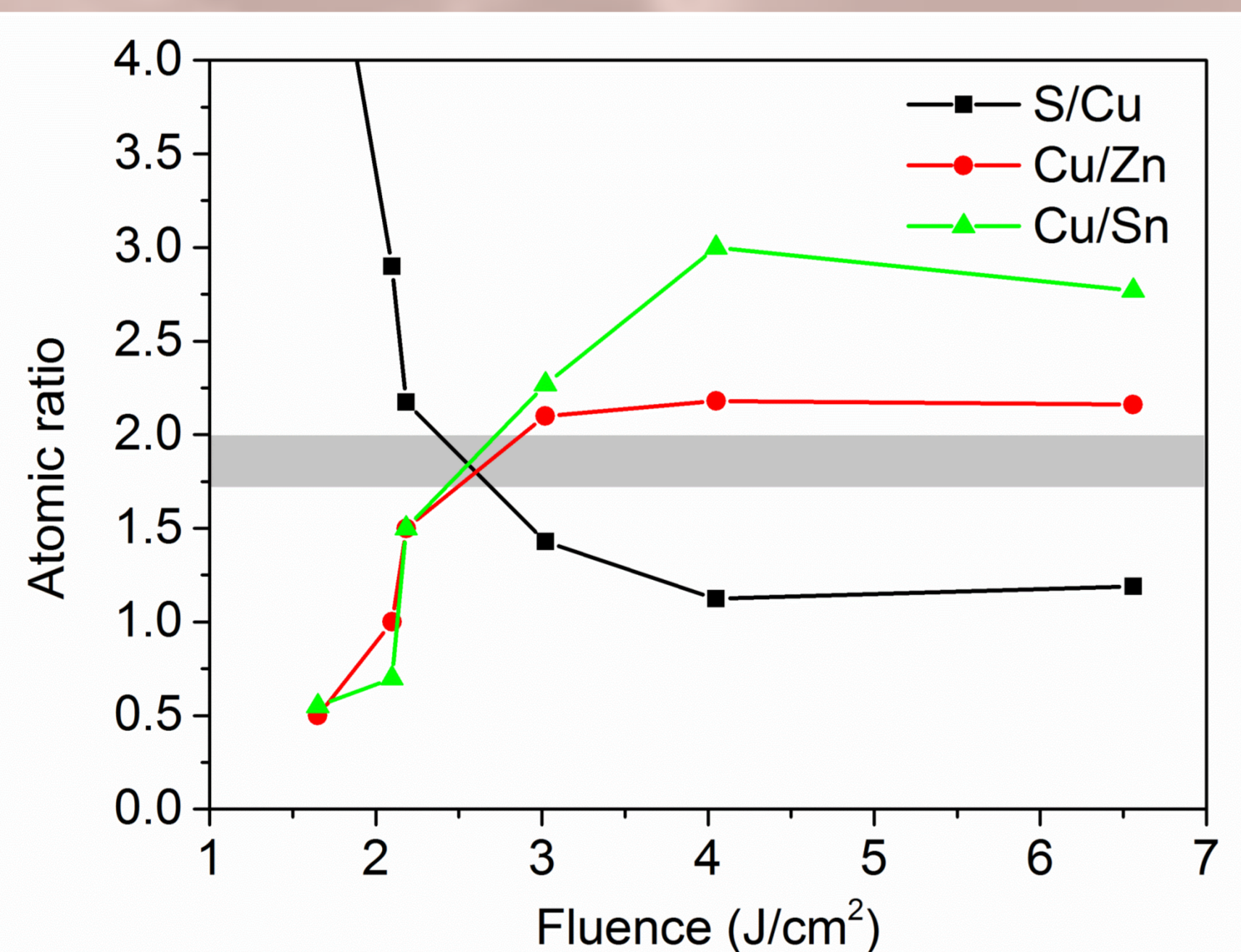
Very low fluence: **evaporation**  
 Very high fluence: **ablation**

## Influence of laser fluence on composition

Copper has the lowest vapour pressure among the 4 elements

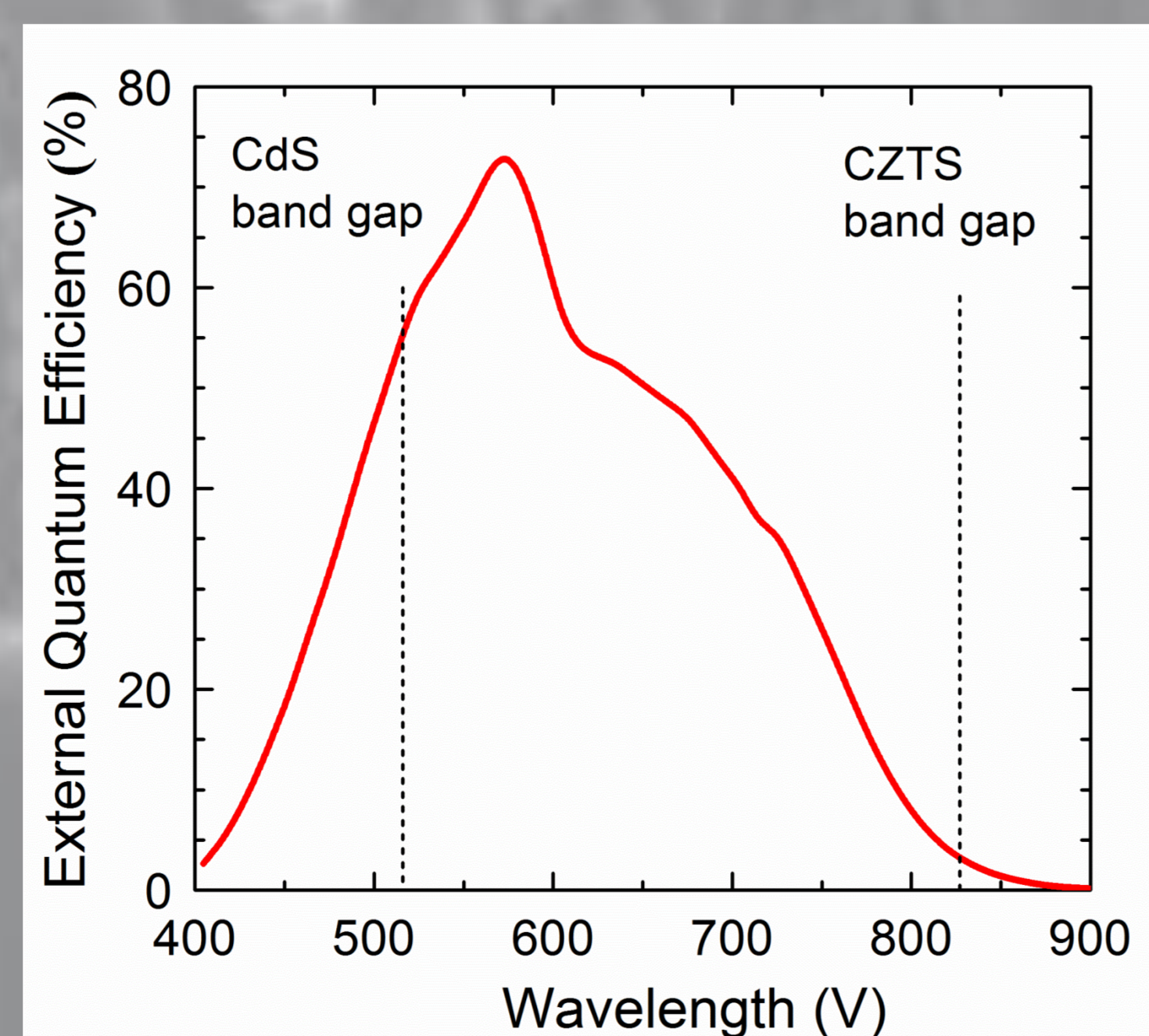
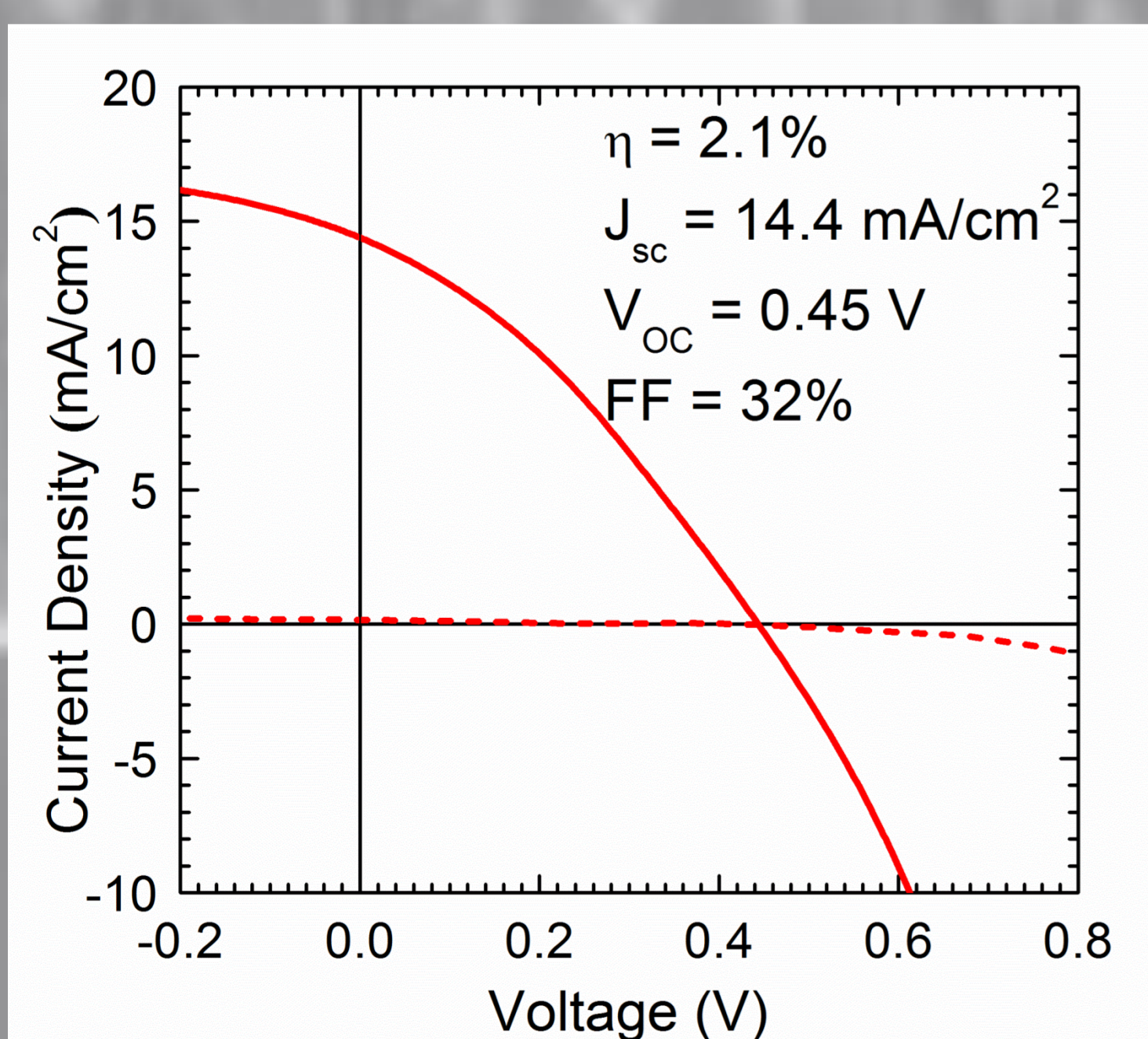
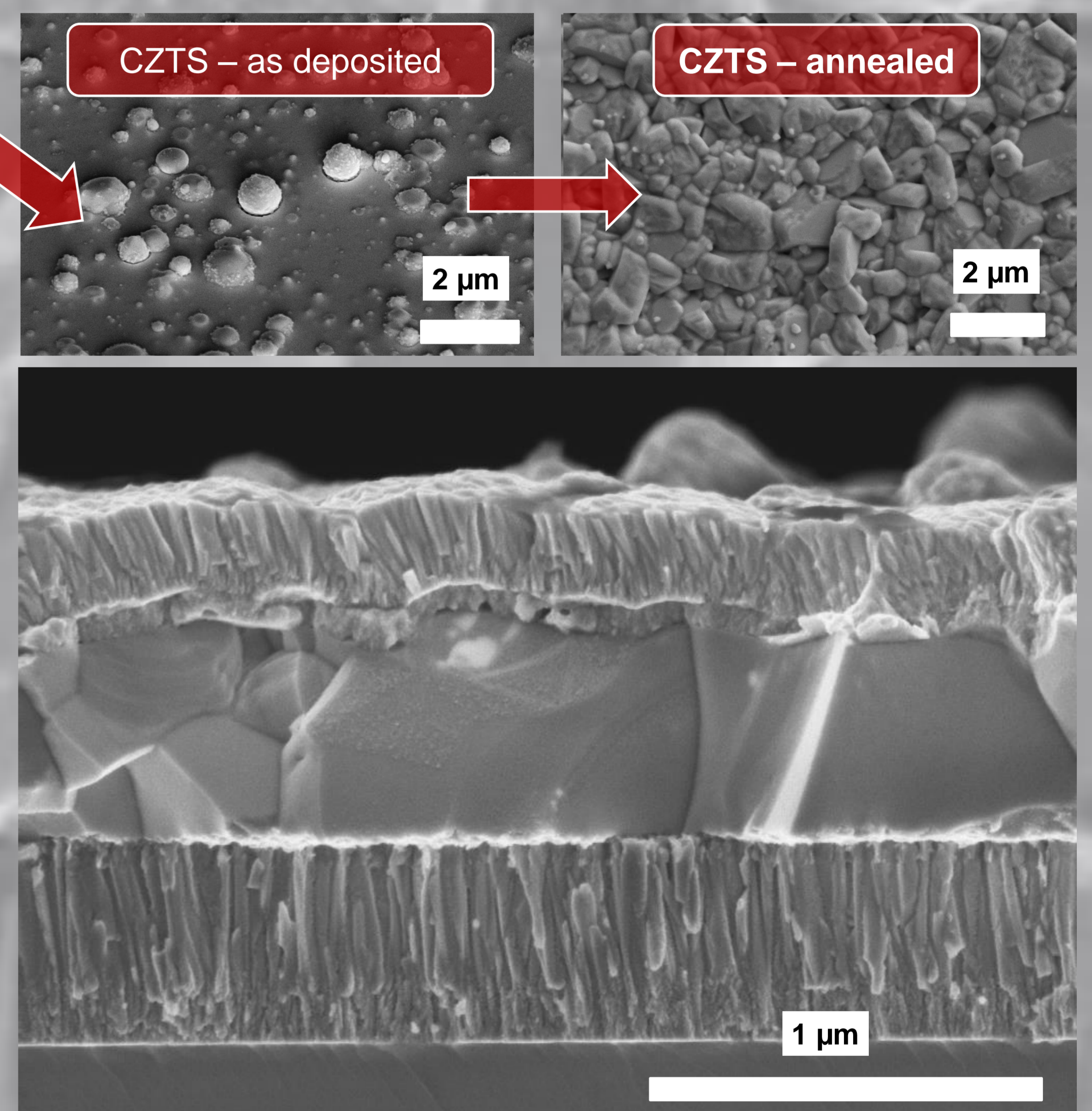


**Tuning laser fluence = tuning %Cu**



At optimal lens position:

Cu: 22.6%; Zn: 14.7%; Sn: 12.2%; S: 50.5%  
 Cu / (Zn+Sn) = 0.84; Zn/Sn = 1.20; Cu/Sn = 1.85

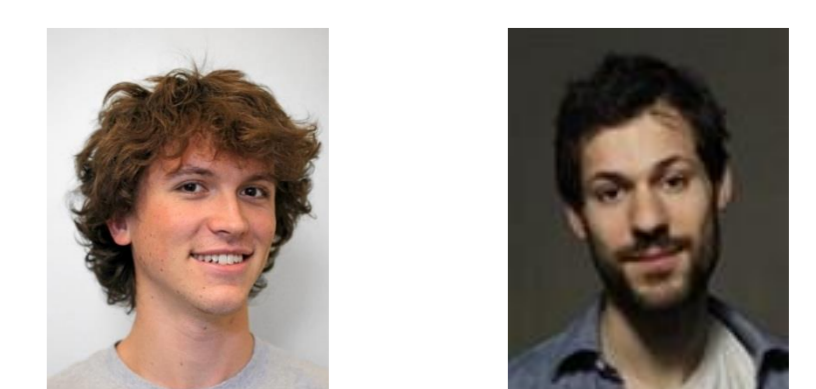


## Conclusions

Solar cell devices	CZTS processing
<ol style="list-style-type: none"> <li>J<sub>sc</sub> and V<sub>oc</sub> are relatively close to best devices</li> <li>Fill factor is very low</li> <li>Extreme light-dark crossover</li> </ol>	<ol style="list-style-type: none"> <li>Compact morphology with large grains</li> <li>Micro-particulate disappears after annealing</li> <li>Radial compositional inhomogeneities</li> </ol>

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