Laser Annealing Novel Substrates for Rutile Thin Films

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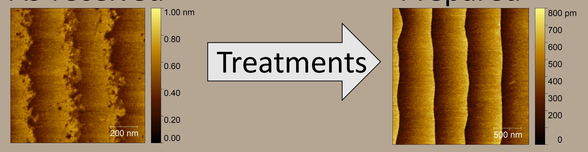
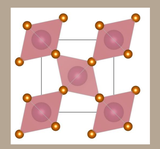
Introduction

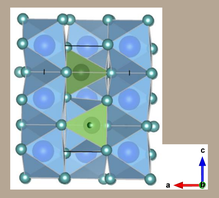
- Superconductivity discovered in epitaxially strained RuO_2 thin films [1]
  - Possibility for other rutile thin films to superconduct
- Need a set of optimally prepared substrates

As-received → Treatments → Prepared

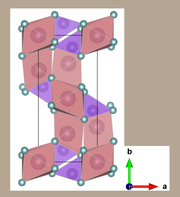


- Desired criteria:
  - Stabile under oxidizing and reducing conditions at high temperatures
  - Rutile-like crystal structure
  - Oxide with octahedral coordination

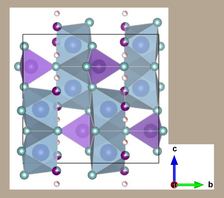




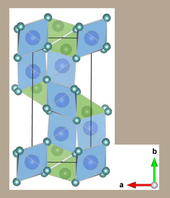
(001) $BeAl_2O_4$



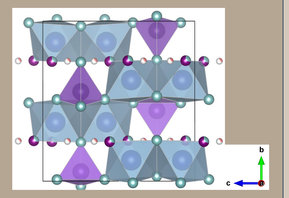
(010) Mg_2SiO_4



(001) Topaz



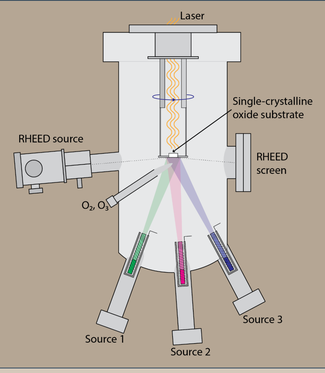
(010) $BeAl_2O_4$



(010) Topaz

Methods

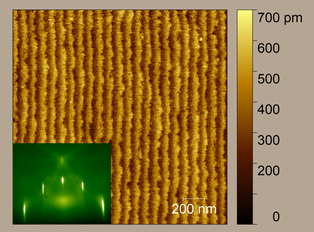
- Laser annealing
- Furnace annealing
- HF acid etching
- Atomic force microscopy



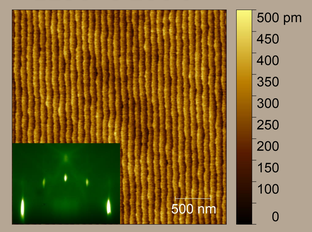
Results

- Laser annealing (001) $BeAl_2O_4$:

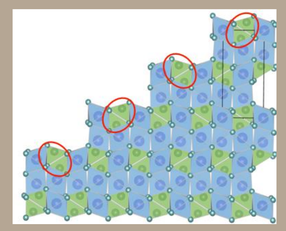
As-received



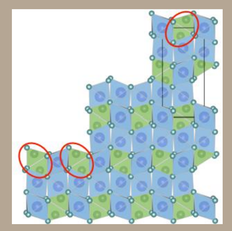
1250˚C 200 s



- Laser annealing (010) $BeAl_2O_4$:
  - Double termination



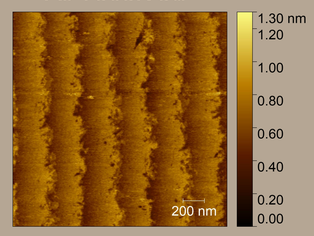
~2/5 unit cell step height (0.37 nm)



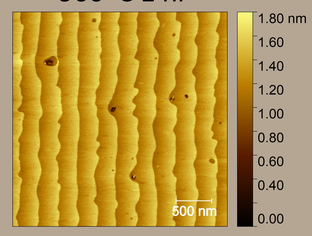
~3/5 unit cell step height (0.56 nm)

- Furnace annealing (010) $BeAl_2O_4$:

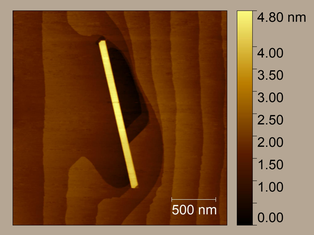
As-received

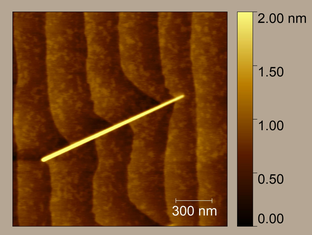


900˚C 1 hr



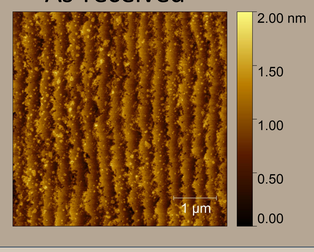
  - Needle defects



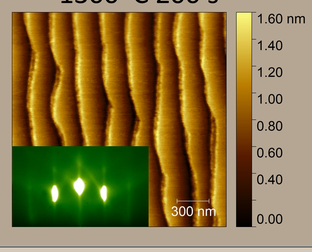


- Laser annealing (010) Mg_2SiO_4:

As-received



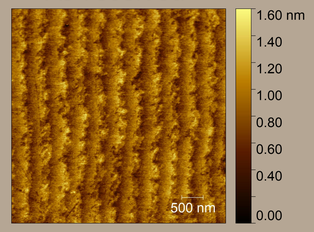
1300˚C 200 s



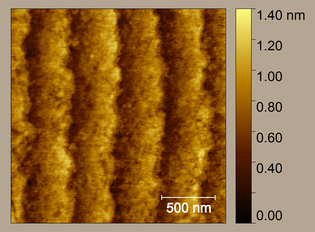
Results (Continued)

- Furnace annealing (001) topaz:

As-received

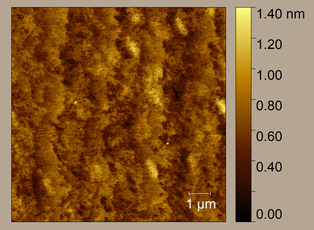


750˚C 1 hr

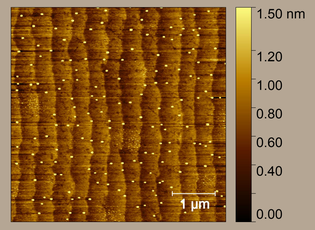


- Furnace annealing (010) topaz:

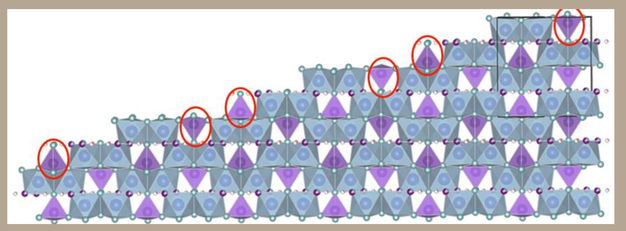
As-received



600˚C 1 hr



- Double termination



~1/4 unit cell step height (0.22 nm)

Conclusions

Successfully developed processes that prepare these substrates for thin film deposition, accelerating the search for superconducting rutiles

Acknowledgements

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References

[1] *J.P. Ruf et al., Nat. Commun.* 12, *(2021), 41467.*