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Development of High Rate Y_2O_3 Seed Layer by Reactive Sputter Deposition for 2G HTS Wire

S. Sambandam, X. Xiong, A. Rar, K. P. Lenseth and V. Selvamanickam

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Challenges in the commercialization of 2G HTS wire

- Three challenges for 2G HTS wire to become commercially viable are *long length, high quality and low cost*
- Long length production of high quality 2G wire presents a challenge because the *yield decreases with tape length*
- *High throughput processing is a must for cost reduction and increasing production capacity to meet market needs*
- Development of process control techniques based on a deep understanding of the process and details is the key to success
- Identification, evaluation, and selection of a high yield, robust process for production plan is critically important
  - Of numerous processes, some are good for lab demonstrations or are of scientific interest, but need further process yield-throughput study and process control technique development to determine if it can be a high yield and robust production

Current processes and tape structure

Al_2O_3 - Reactive sputtering
Y_2O_3 – Reactive sputtering (oxide mode)
MgO – RF sputtering
$LaMnO_3$ – Reactive sputtering

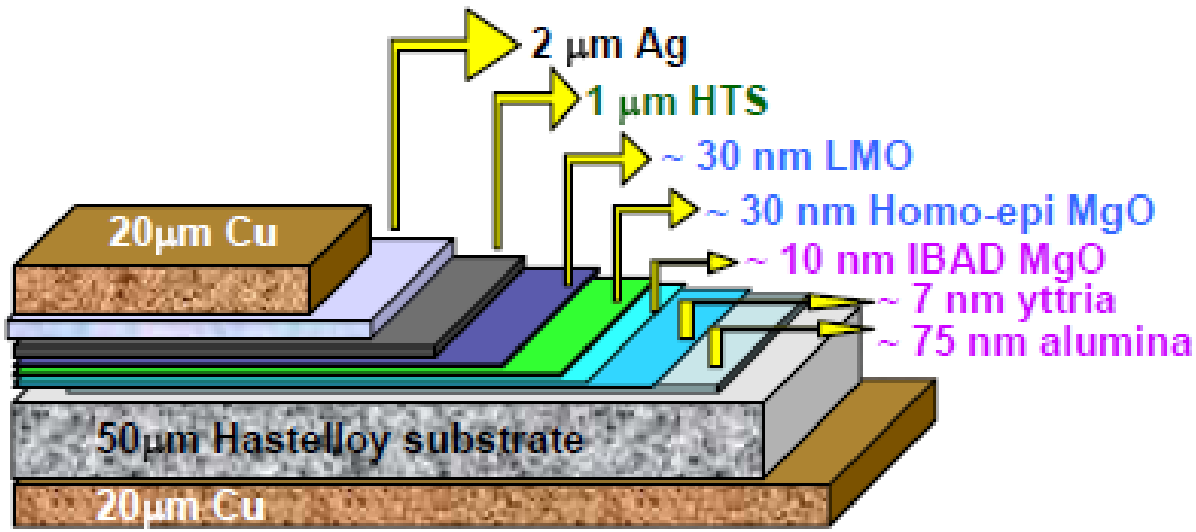


Fig.1. Structure of SuperPower's IBAD MgO-based HTS wire

Bottlenecks in Buffer processes

- Currently Al_2O_3 and Y_2O_3 processes are made in a single run with our Pilot Buffer system using reactive magnetron sputtering
- As previously reported (X. Xiong et al, ASC 2008), the use of reactively sputtered Al_2O_3 and Y_2O_3 films were proved to be of good quality as of IBAD processes originally reported. Same texture and Ic as IBAD prepared Al_2O_3 and Y_2O_3 had been demonstrated over long lengths
- Working at the transition mode in the reactive sputtering to get tape speed of > 5000 m/h in our Pilot Buffer system. Currently the tape speeds are 250 m/h
- This work aims to stabilize the Y_2O_3 reactive magnetron process in the transition region to increase throughput

Y_2O_3 Reactive Sputtering

- Reactive sputtering of Y metal target in oxygen exhibits a sharp transition with large hysteresis
- Sharper transition and large hysteresis calls for fast response feedback controls for stability (avoid drift) and repeatability
- A robust feedback control was necessary with fast response times (< 1sec) with multi parameter feedback loop

High Rate Y_2O_3 sputtering

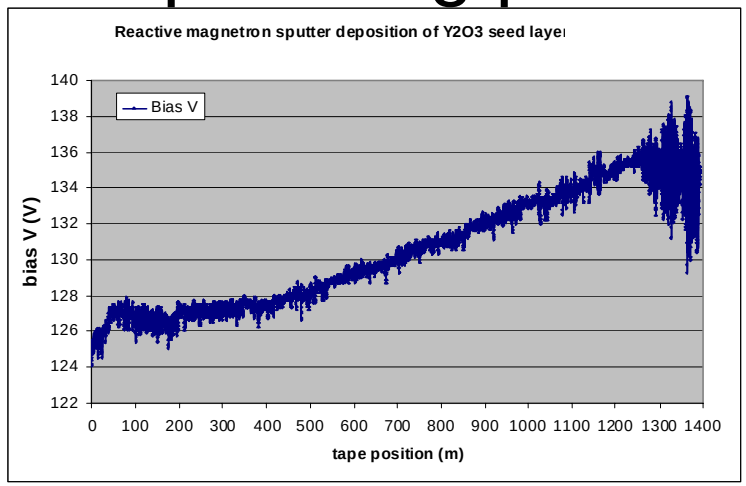
- Y_2O_3 reactive sputtering was stabilized at the transition and films were deposited
- Thickness was determined using spectroscopic ellipsometry and found to decrease exponentially from metal to oxide mode
- Process conditions were optimized to yield tape speeds of 144 m/h at 600W RF power with 3 wraps
- For same conditions above, production system can run Y_2O_3 processes at more than 1000 m/h. It can be further raised to 2500 m/h by increasing RF power

Ellipsometry model

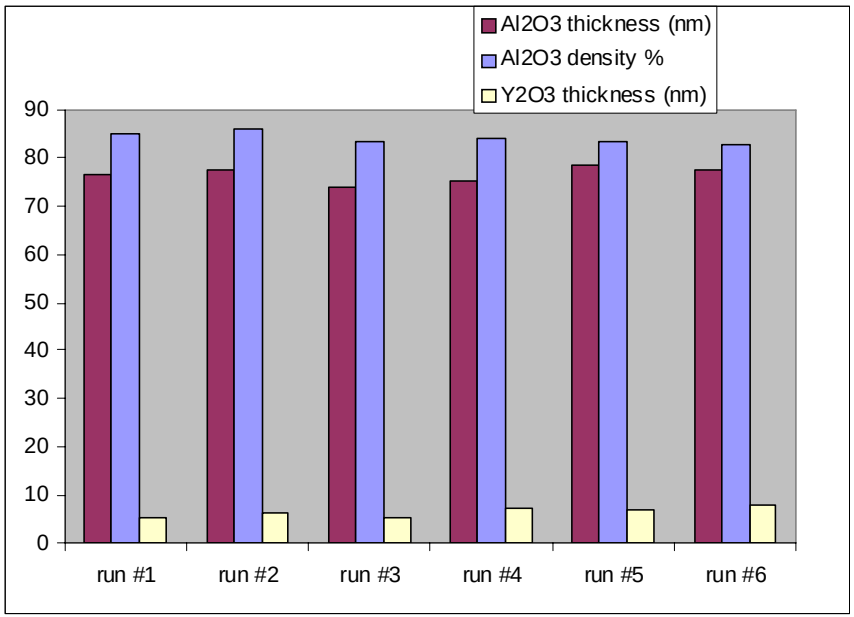
Refractive index 1.8 to 1.95

Stable Alumina-Yttria reactive sputtering process

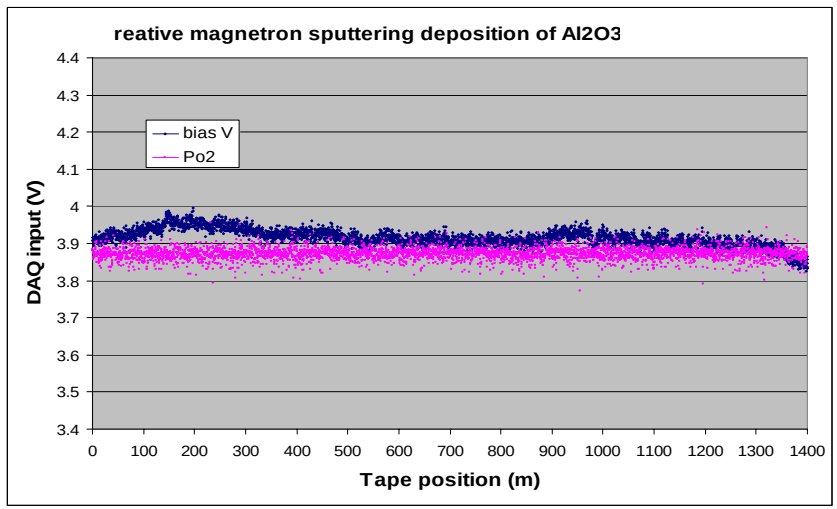
Reactive sputtering has high throughput, but very delicate, feedback control on single parameter, in most cases, is not enough to get stable process over long time and from run to run. Stable reactive processes for long length production were developed at SuperPower with MPML (multi-parameters/multi-loop) feedback control.



Bias voltages run away in Yttria run. single feedback control

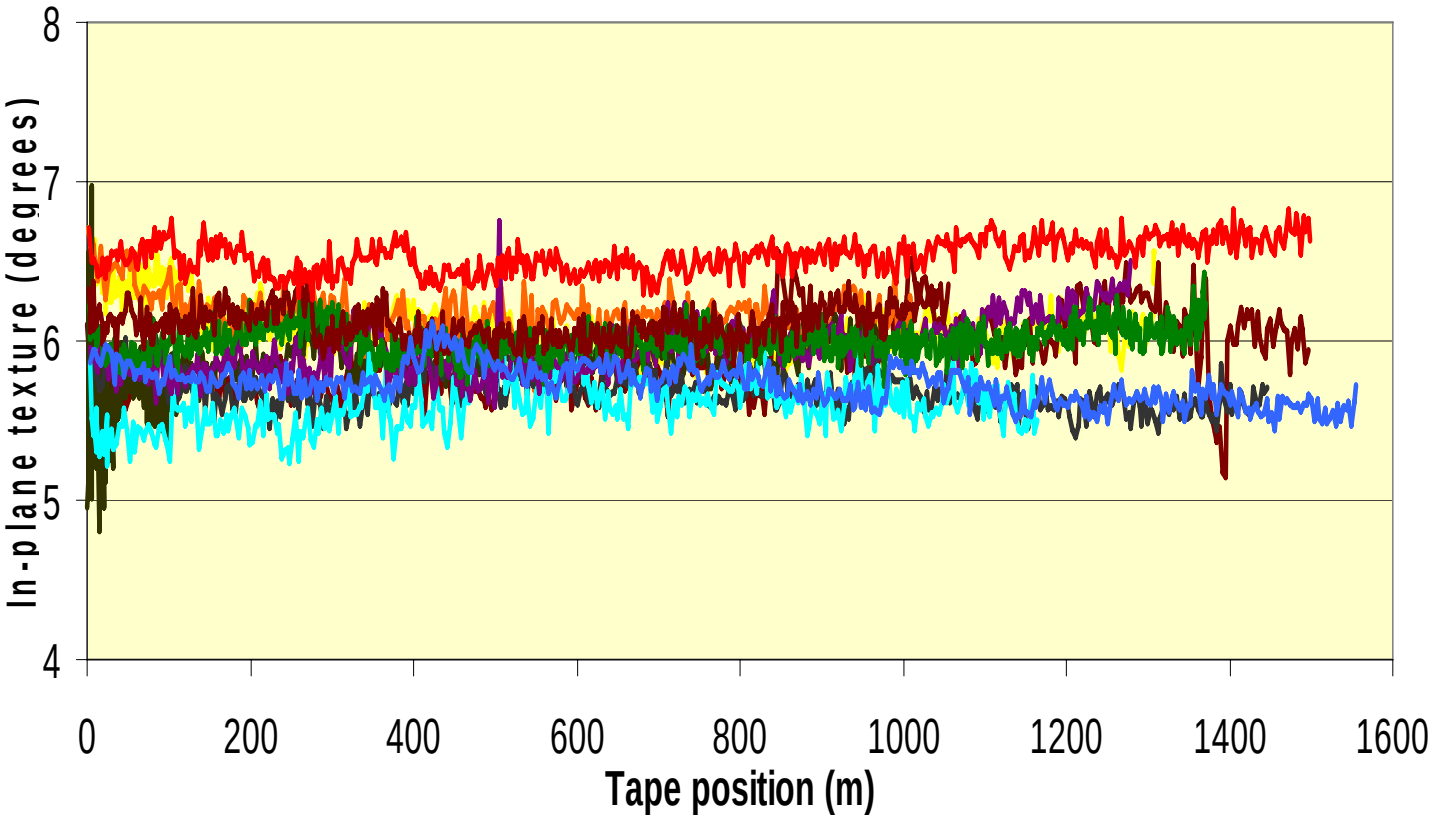


Good stability from run to run



Good stability during run. MPML feedback control

Routine high throughput manufacturing of kilometer lengths of high quality, low cost IBAD buffered tape



Conclusions

- Good understanding of the process and robust process control is a must for producing long length, low cost 2G HTS
- Y_2O_3 reactive sputtering process yield 10 times higher throughput when stabilized at the transition with help of multi-parameter feedback control