Coating Discussion

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Coating Discussion Topics

- **Future of Mexican Hat Experiment**
- **Advanced LIGO Coating Design**
  - Optimization
  - Second Wavelength Transmission
- **Next Generation Research**
  - Coating Runs and Schedule
  - Funding Plan
  - Measurements
  - Samples
- **Scatter**

Advanced LIGO Coating

- **Silica mechanical loss**
  - Reconcile HWS and Glasgow numbers
  - ϕ appears to be a few x 10^{-5}

⇒ **Optimized design for low thermal noise**

⇒ **Transmittivity at all wavelengths**

- **What issues remain?**

Next Generation Coating Conservative Approach

- Work with materials/techniques we are familiar with
  - Silica: need good ϕ for Adv LIGO, cheap and easy to coat, interesting behavior with annealing, good loss theory
  - Titania – tantala – silica: All three work well alone and together, can fine tune Y (si) and n (ti) and ϕ (ta)
  - Neon as ion: argon to xenon made ϕ worse so try lighter ion, material structure known to depend on ion
  - Secondary ion beam deposition : clear differences with different masks, known to effect material structure
- Advantages – not much theoretical guidance so stays with what we know, vendor familiarity, likely cheaper, results quicker, can buy time for modeling and theory to advance
- Disadvantages – probably won’t make big gains in performance, limited theoretical input, might learn more about causes of loss from new materials

Next Generation Coating Aggressive Approach

- Work with new materials and techniques
  - Alumina: especially as dopant, optically acceptable
  - Cerium oxide (and other amorphous oxides): transmissive with low absorption
  - Lanthanum: dopant, used with titania
  - Fluorides: used for IR coatings, usually low stress, low index
  - Selenides: high index, low stress
  - Magnetron sputtering: improves uniformity, depresses crystal growth
  - B, N (other small atoms) as dopants: improves glassiness
  - Very thin layers: possibly less mechanically lossy
- Advantages – more likely to find big improvements (?), learn more about causes of loss from studying more materials, drawn on X-ray experience, new techniques since initial LIGO
- Disadvantages – more likely to find nothing, possibly more expensive, no theoretical guidance

Research Coating Runs - Conservative

- Approach – 2 Advanced LIGO runs (silica, bubbles), 2 follow up runs (SIBB, si-ti), 2 new ideas drawing from previous experience (ti-ta-si, neon)

- March – MLD, 2 silica runs. 0.5 micron on silica cantilever, 2 microns on silica disks
- April – CSIRO, trinary alloy of titania/tantala/silica
- May – ATF, neon as bombardment ion for tantala/silica
- June – JDSU, secondary ion beam bombardment with oxygen of titania-doped tantala/silica – MLD, follow up runs (silica
- July – REO, silica doped titania – CSIRO, follow up runs
- August – LMA, AdvLIGO development run on either uniformity or bubbles – ATF, follow up runs

Research Coating Runs - Aggressive

- Philosophy – 2 Advanced LIGO runs (silica, bubbles), 2 new ideas with some tie to experience (oxide, alumina dopant), 2 radically new ideas (fluoride, magnetron)

- March – MLD, 2 silica runs. 0.5 micron on silica cantilever, 2 microns on silica disks
- April – CISRO, new oxide (Z, Ce, etc)
- May – ATF, alumina doped titania
- June – JDSU, fluoride – MLD, follow up runs
- July – REO, magnetron sputtering (as available) – CSIRO, follow up runs on new oxide
- August – LMA, AdvLIGO development run on either uniformity or bubbles – ATF, follow up runs with alumina or other dopant

Payment System

- Multiple groups contribute to cost of coating research
- One or small groups pay for each coating run

- March: MLD - Syracuse and HWS
- April: CSIRO - LIGO MIT
- May: ATF - Stanford
- June: JDSU - LIGO Caltech
  MLD - ERAU , Florida, and Southern
- July: REO - Glasgow
  CSIRO - TBD
- August: LMA - Caltech AdvLIGO funds
  ATF- TBD

Measurements

Mechanical Loss	HWS, ERAU, MIT	**Direct Thermal Noise**	TNI - Caltech
Cryogenic Q	Glasgow, Perugia	**Index of Refraction**	Vendors
Absorption	Stanford, Vendors, Caltech	**Young’s Modulus**	Glasgow, Vendors, Ole Miss, MIT
dn/dT	ERAU, Stanford?	**Structure and Contaminants**	Glasgow, JDSU, Southern
Scatter	Syracuse, Caltech, ERAU	**High Power Effects**	Florida, UWA, Caltech
Transmission	Caltech, vendors	**Non-Gaussian Noise**	MSU
Thermoelastic Parameters	TNI – Caltech	**???**	???

Samples

- Five 1 in X 0.25 in
  - Absorption - Stanford
  - Scatter - Syracuse
  - Thermoelastic parameters - TNI
  - Quarter at Ole Miss
    - Young's Modulus - Ole Miss
    - Structure - Southern
    - Structure - Glasgow
    - Extra
  - Extra
    - Charging – Trinity, MSU
    - High Power – Florida
    - Young's modulus – nanoindenter MIT, Glasgow
- Two 3 inch X 0.1 in
  - Q and *dn/dT* – ERAU
  - Q – HWS, MIT
- Two silica cantilevers
  - Cryogenic Q - Glasgow
- 4 in X 4 in TNI mirrors as needed
  - Direct thermal noise - TNI