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Subject: Re: requirements for blemish absorption
Cc: pf@ligo.mit.edu, mike@ligo.mit.edu,
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Here is Ryan's answer to the question that was posed in the COC telecon a while ago on the allowed blemishes. Ask Ryan (and Peter/Mike) for clarification if needed.

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Hi David,
I did some calculations and, after a conversation with Peter, arrived at the
requirement of:
(peak-to-valley absorption)*(feature area) < 3*10^3 ppm mm^2
for any small (less than 6 mm in diameter) area of inhomogeneous absorption.
Ryan

>
>Just to be clear, this is the requirement on the coating/substrate
>absorption to put it on a scale and magnitude such that the laser-scanning
>system (or the sum of radiative and laser?) can correct it to meet Adv LIGO
>performance?
>
>what is the lower size scale where the relationship no longer holds?
>
>thanks d.
>

The requirement is on the total peak-to-valley absorption through the substrate (coating absorption + bulk absorption integrated over the optical path through the substrate) over a small patch of anomalous absorption. It holds for features smaller than 6mm in diameter, which we can only partially compensate since an actuating beam smaller than 6mm is probably not such a good idea (duty cycle considerations taken into account, as well as the photothermal noise induced by a tight beam). To get the requirement, I look at the approximate distortion induced by small features of various sizes in the center of a LIGO II ITM with a 6cm waist, 1 kW beam illuminating it. I then "compensate" it by taking subtracting off the distortion created by the compensating beam (best fit in amplitude, of course). This kills off a good chunk of the distortion, except for a sharp bump smaller than the actuator beam, right in the center of the optic. I then calculate how much power is scattered out of the main beam (the 6cm one) by the compensated distortion, calling 1000 ppm of scattered power to

be the limit. I've assumed we can compensate features larger than the actuating beam size, so I have not considered larger features.

I've attached the plot which shows the result of this calculation for compensator beams of various sizes. The whole calculation is a little rough (meaning not exact), but it is still a slightly-better-than-ballpark estimate.

The calculation is for one circular absorbing patch in the center of the beam. While this is the worst spot for the absorption inhomogeneity to be, there will potentially be multiple such patches (a continuum in fact), so if we stick with the upper limit of 1000 ppm of power scattered out of the mode (not sure it's the right target), each patch would have to satisfy a smaller/stricter requirement (adds Peter).

Ryan

homogeneity_req.tif

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