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# Terahertz application: CMP monitoring and thickness determination

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In this note we demonstrate application of terahertz transmission measurements for monitoring silicon wafer polishing via thickness removed on the nanometer scale. Also, thickness monitoring of transparent celophane paper is demonstrated. The data are presented and explained in terms of the applicability of the technique in respected areas.

## 1. CMP monitoring for wafer polishing

Chemical and mechanical poloshing (CMP) process for Si-wafer planarization requires sufficient material to be removed, but too much can result in failure/rejection of the wafer. As such thickness control on the order of nanometers are required for low reject rates. Terahertz transmision measurements can be used for monitoring CMP process. Here a piece of Si-wafer (Fig. 1) was polished on a 800-grit paper, weighed after every polish, mounted on the THz spectrometer and transmitted power (counts) were recorded. Fig. 2 shows that as the mass is removed by polishing, the transmitted power increases successively for each polish. The results are shown in Fig. 3 for the actual mass removed. Fig. 4 shows the calculated thickness vs. the change in measured power (in counts).

The slope of Fig. 3 indicates that for each mg mass removed, the counts difference, ~21.718 million. From Fig. 4 it is evident that for each nm of Si-wafer removed the count difference is 8.15 million. The noise floor of the detection system is ~<1 million counts. Thus, the uncertainly in the thickness data of Fig. 4 is <1 nm. Therefore, here we have demonstrated that THz

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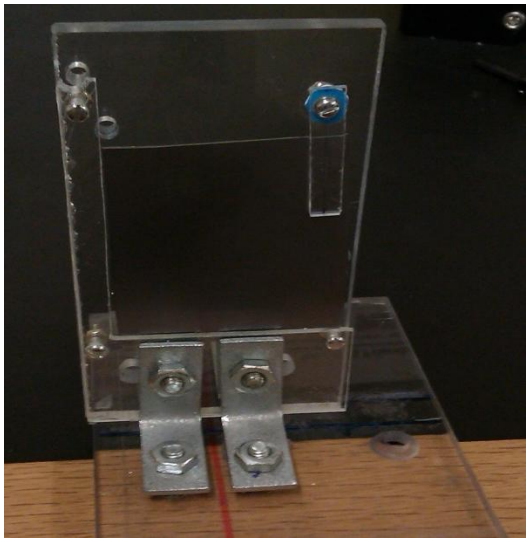

Fig. 1. A piece of Si-wafer mounted on a fixture for polishing experiment and analysis by THz spectrometry. The mount ensures positioning of the wafer at the same place after every polish.

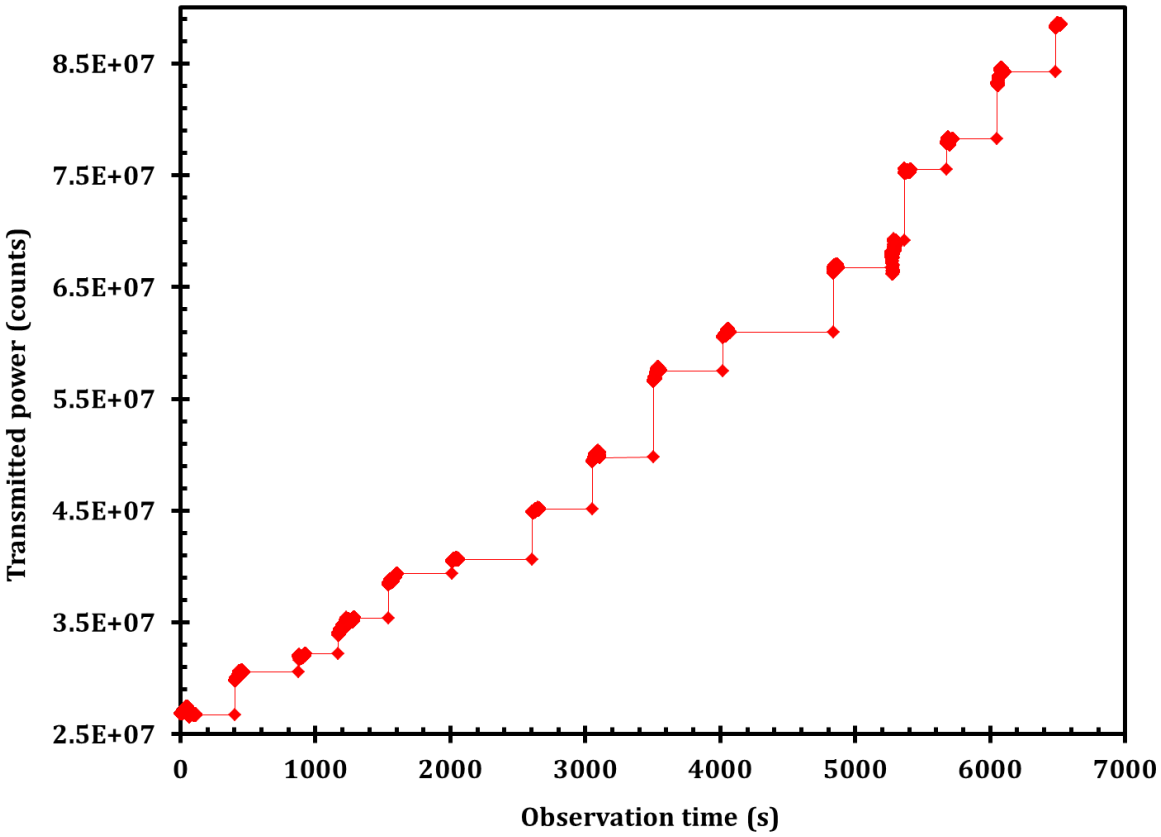


Fig. 2. Transmitted power (counts) increases as a function of removed mass of wafer by polishing.

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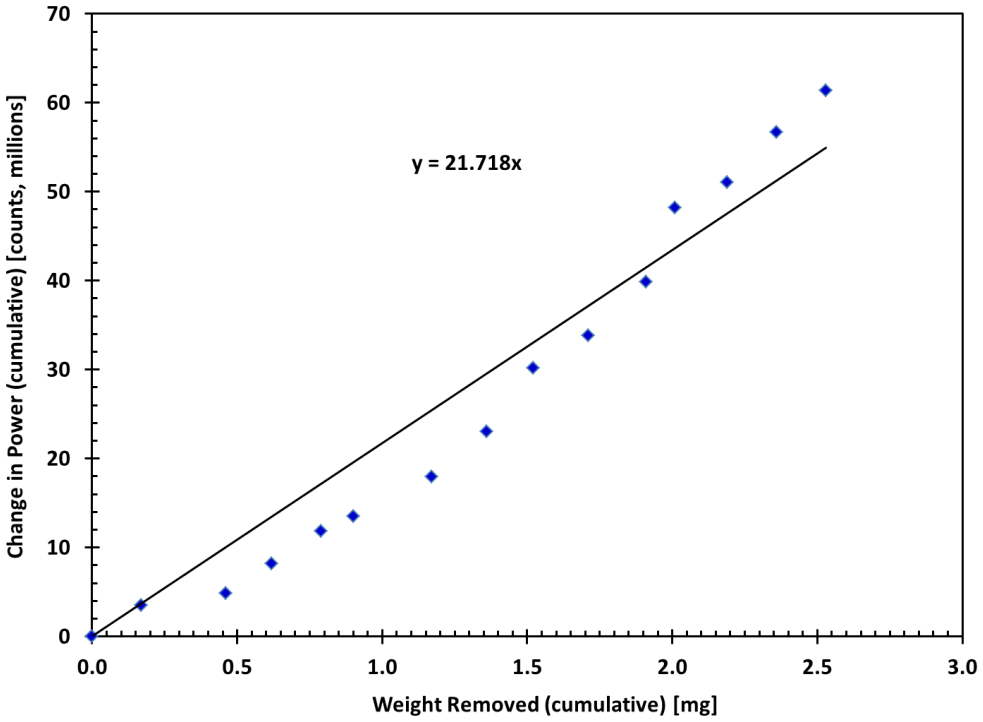


Fig. 3. Measured counts (transmitted power) vs. mass of Si-wafer. The data can be fitted by the quadratic eq. y (million) = 21.718x.

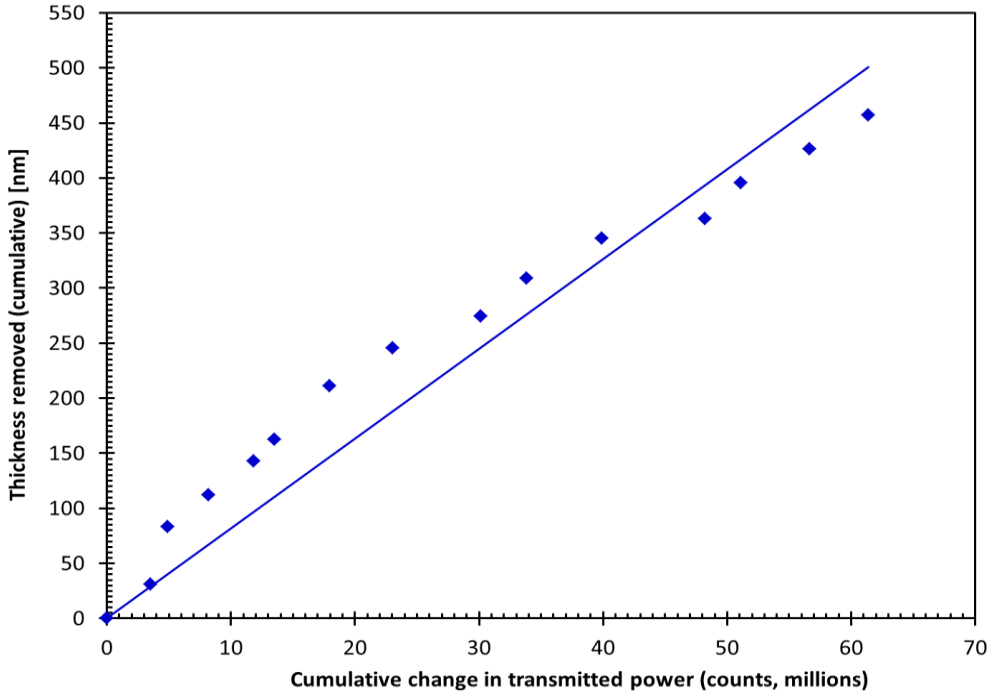


Fig. 4. Computed cumulative layer thickness removed vs THz transmitted power (counts). The data is fitted by y = 8.15x, where x is in millions.

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spectrometry can be used for high precision monitoring and of wafer CMP process. Thus, a control system operated by this monitoring system is expected to maintain high level of uniformity of the CMP process. However, the actual CMP process involve use of polishing slurry and other chemicals. Therefore, the performance of this system must be determined via calibration for an actual CMP system. In addition, different calibration will be necessary for different slurry and polishing protocol combinations.

## 2. Thickness determination of papers and coatings

Terahertz transmission technique can also be used for determination of thickness of papers and/or coatings on papers. The present demonstration used a 0.04" thick cellophane paper that was cut in to ~2"x2" pieces. These pieces were stacked one at a time to increase the total thickness. Fig. 5 shows

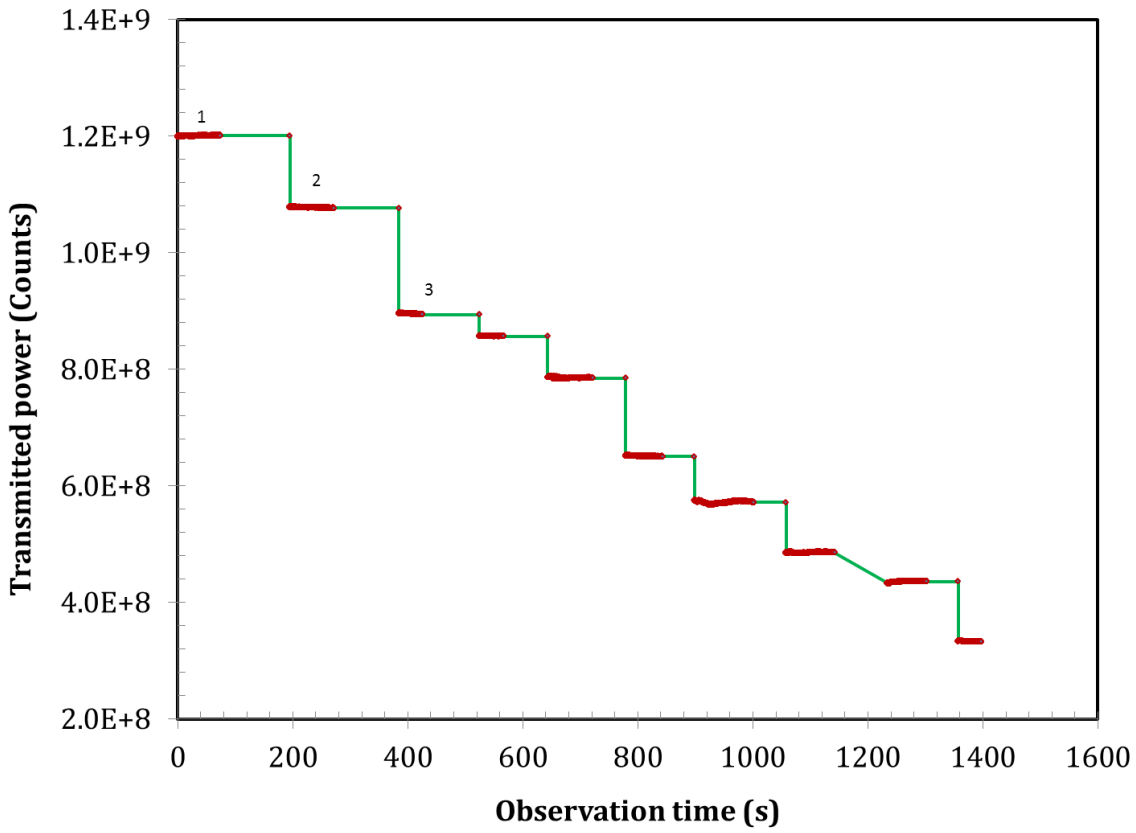


Fig. 5. Transmitted power (counts) decreases as a function of increasing number of papers in the stack.

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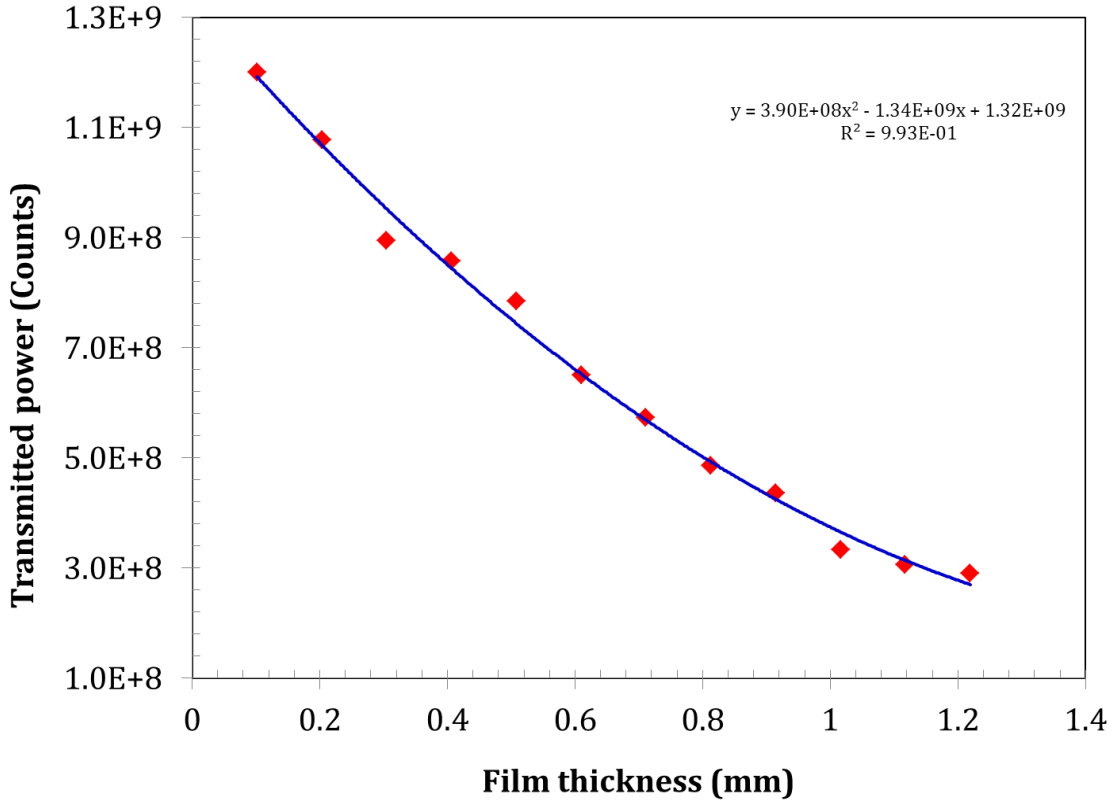


Fig. 6. Transmitted power vs. thickness of cellophane paper. The data can be fitted by the quadratic equation:
$y = 3.9x10^{8}x^{2} – 1.34x10^{9}x + 1.32x10^{9}$; $R^{2} = 0.99$

a plot of transmitted power at increasing thickness of cellophane paper where each successive step corresponds to addition of one paper to the stack. Fig. 6 shows the transmitted power vs. thickness of the stack. The scatter in the data is most likely due to flaw in stacking up sheets. Also, even a small smudge will make major difference in transmission.

## Summary

In summary, this note demonstrates THz transmission spectrometry can be used with high precision for monitoring and controlling wafer CMP process. It can also be applied for high precision thickness monitoring of paper. The

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technique may be extended to other substrates transparent to terahertz radiation.

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