Solar Technology: Monitor ungrounded targets

Today's semiconductor and solar industries drive the demand for higher density chips with smaller critical dimensions. To meet this demand, wafer fabricators seek greater dimensional control of their silicon products.

Non-contacting capacitance sensors offer the precision, accuracy, and speed needed to measure flatness, thickness variation, and other critical dimensions. Typically, the sensor acts as one plate of a classical two plate capacitive gap measurement scenario. The grounded target – i.e. the silicon wafer – forms the second plate.

Grounding, however, presents challenges. First, it can scratch or damage the wafer which is fragile and expensive. Second, it prohibits those sensing scenarios where the wafer must be moved to acquire all metrology measurements.

While there are ways to overcome the grounding challenge – parasitic capacitance coupling, a second sensor working 180 degrees out of phase, or a grounded chuck to support the wafer – they offer limited effectiveness. Here is a better solution: a push-pull probe specifically designed for ungrounded targets.

Challenge: Measure the thickness and warp of 156 mm^2 photovoltaic (PV) wafers as they pass at the rate of one wafer per second. The required accuracy is < 1um.

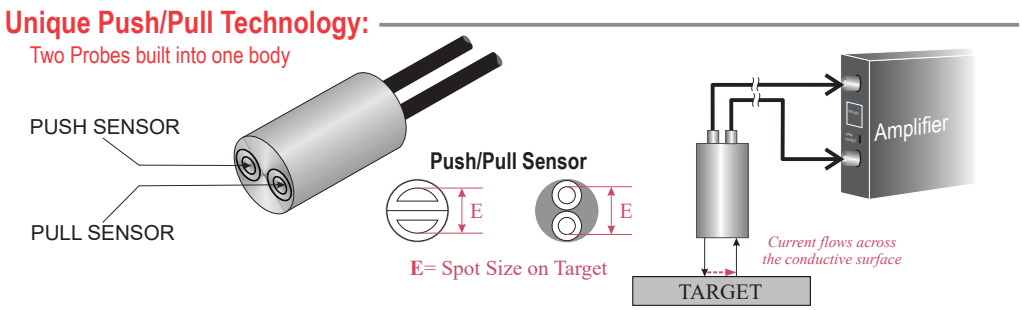
Solution: In the scenario described above, it is virtually impossible to ground the wafers as they pass by the capacitance probes. Even if it were possible, poor grounding would introduce unacceptable noise to spoil the results.

MTI's proprietary push-pull probe systems measure ungrounded semiconductor wafers. Based on conventional capacitance measurement principles, the design features two capacitance sensors built into one probe body. Each sensor is driven at the same AC voltage with a 180 degree phase shift between signals. The shift allows the current to travel across the target surface rather than through the target to ground, eliminating inaccuracies created by poorly grounded targets.

MTI's AS-562-PP amplifier sums up the individual output signals, producing a single 0 to 10 VDC output that is proportional to the probe-to-wafer gap. Sub micron accuracy is achieved at probe standoff distances up to two mm.

Benefits

- Push-pull probes are passive and extremely stable over a wide temperature range
- Push-pull technology can be used on high bulk resistivity targets
- There is no need to recalibrate the probes for changes in target material
- The push-pull amplifier design cancels common mode electrical noise that may be induced in the target
- MTI's PV-1000 digital controller accepts three capacitive thickness channels and provides digital correction for very high linearity and performs other digital functions such as wafer sorting commands, pass/ fail metrology computations.



The Push-Pull probe is a unique version of MTI's Accumeasure™ amplifier series. This special design provides accurate surface information for wafer bow and thickness.

Today's cars and trucks offer unprecedented fuel efficiencies and handling characteristics – thanks, in part, to vehicle lightweighting. Applied to all vehicle components, lightweighting lowers stress and strain to improve mileage and boost overall performance.

In keeping with this trend, today's brake rotors are thinner and lighter than those of just a few years ago. In addition, many feature cooling vents to further improve performance. These changes, however, reduce available braking surface, forcing automotive engineers to consider alternative materials and designs.

Challenge: Because the extreme temperatures and forces generated during braking can easily lead to rotor distortion and failure, dynamic testing of any new design is mandatory. Data on disk runout, thickness variation, coning or warping, and temperature must be continuously collected to evaluate how prototype units respond to real life conditions.

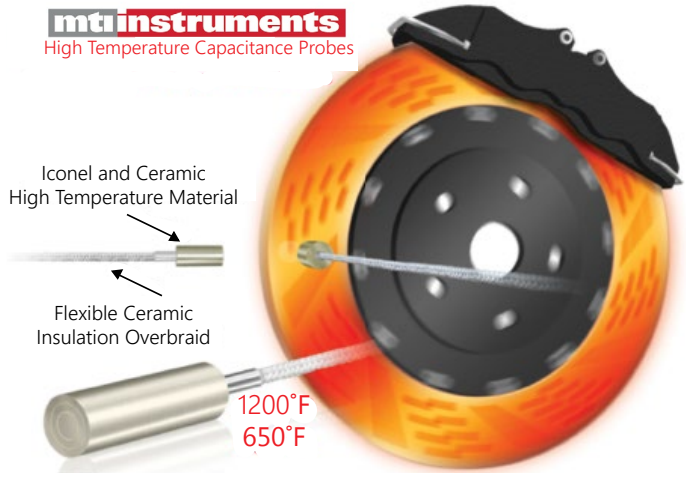
Solution: MTI's newest multi-channel brake rotor measurement system, the Accumeasure™ D Series, satisfies the requirements of both test scenarios. The amplifier uses advanced technology to change a reliable capacitive electric field measurement into a highly accurate 24 bit digital reading. This eliminates errors related to analog filtering, linearization, range extension, and the summing of channels.

Either single-ended capacitance probes or "push/pull" capacitance sensors monitor the distance between probe and rotor while spinning. With push/ pull, two sensing elements built into one probe body eliminate the need to electrically ground the rotor. Made from Inconel and ceramic materials, the non-contacting probes can withstand temperatures reaching 1200° F (650°C).

Several major vehicle manufacturers have standardized on MTI's Accumeasure high-temperature sensors and the Accumeasure™ D Series amplifier for their testing requirements. In addition to brake testing, these products are being used to measure and monitor spindle and shaft runout, engine vibration, thermal expansion/contraction, and suspension travel.

Digital Benefits

- The digital Accumeasure is a compact unit that runs off 24VDC. It provides either four channels of single ended probes for a grounded target or two push pull probes for ungrounded rotors.
- Digital linearity correction allows longer range probes to stay away from the hot rotor surface without losing accuracy.
- Digital Accumeasure features include high linearity for accurate measurements, Ethernet and USB ports, and probe range extension for large stand-off distances.



MTI's Accumeasure™ D Series amplifier provides up to four independent measurement channels in a rugged, compact amplifier package. Features include multiple unit synchronization, range extension, sub-micron resolution, and 0.01% error of full scale linearity. Push/pull probe design permits groundless, non-contact measurement of rotating targets.

The adverse effects of water in oil are well known. Negative consequences include:

- higher viscosity
- reduced load carrying ability
- hydrolysis (the formation of acids, sludge, and varnish)
- foam formation and air entrainment
- additive depletion
- corrosion on metal surfaces
- loss of lubrication film strength leading to increased wear
- cavitations
- filter plugging

Challenge: As oil system reliability decreases, maintenance and repair activities increase. Corrective action must be taken before an "out of limits" situation occurs if escalating operational costs are to be avoided.

Solution: In-line capacitance probes can be used to automatically and continuously monitor water infiltration into lubrication systems. Typically, oil has a dielectric constant in the 2-5 range. Water has a dielectric constant of 80, so even minute amounts of water will significantly alter the water state reading.

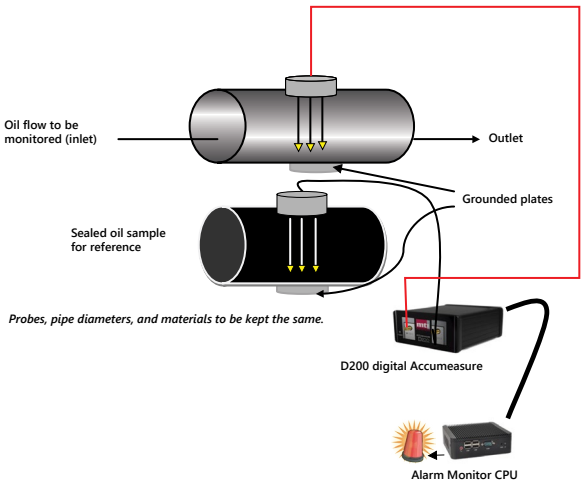
To work, place one capacitance probe against a non-conductive section of piping that carries the oil supply to be monitored. A second reference probe is placed against a sealed, non-conductive tube containing a sample of the lubricating oil. Both tubes should be in thermal contact with each other. MTI offers flat flexible capacitance probes that can be easily bonded to the tubes.

Each capacitance probe measures the dielectric field between the face of the probe and the grounded plate on the opposite side of tube. A monitoring CPU triggers an alarm if the dielectric reading for the oil flow channel diverges from the sample reading.

By continuously measuring capacitance of the oil ratio to oil/water mixture through the tube, moisture level can be minimized, corrosion eliminated, and system reliability enhanced. Maintenance moves from a reactive to a proactive mode.

Digital Benefits

- The digital Accumeasure has a special calibration program built in to handle dielectric calibrations such as these.
- The digital Accumeasure can also communicate with an off the shelf USB alarm module to make a complete alarm system.
- Digital Accumeasure runs on commonly available 24VDC.



MTI's flexible, off-the-shelf flat probes easily bond to the tube with epoxy to mold to the shape of a plastic/glass oil tube and continuously monitor the capacitance of the oil or oil/water mixture passing through. The company's D200 Digital Accumeasure serves as the monitoring sensor signal conditioner. Immune to thermal drift and easily calibrated to the sensitivity of water in oil, it is available with a digital limit alarm module.

This is just some of what you'll need to know about capacitance-based measurement. That's why it's important to choose the right partner, too. To learn more about MTI Instruments products visit www.vitrek.com, e-mail MTISales@vitrek.com or call (800) 342-2203.

Since 1961, MTI Instruments has been a leading provider of non-contact physical measurement tools and condition-based monitoring systems, including capacitive sensing systems. Our products – used worldwide by clients requiring the highest levels of accuracy – span most industry sectors. From transportation and power generation to factory automation and consumer electronics, precision is our passion. A US-based company, MTI Instruments is ISO 9001:2015-certified.