Enhanced Sop #63 (Nomenclature)
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Title:

Lapmaster Model 15C Lapping and Polishing Machine Nomenclature, Terminology, and Process Variables

View the nomenclature diagram first.

Understanding the Lapping and Polishing Process Variables

These variables independently and collectively control material removal rates and uniformity for lapping and polishing processes.

1. Abrasive slurry **grit size** (typically 1, 3, 9, 12, 15, 20, or 30 μm size "particles"). Choosing to use larger grit sizes for lapping will result in faster material removal rates.
2. **Volume flow rate** of abrasive slurry grit or polishing solution. Higher flow rates result in faster lapping or polishing.
3. The total of all **applied weight or total pressure** on top of the sample being lapped or polished. Higher applied weights result in faster lapping or polishing.
4. For lapping, the **mixing concentration** of abrasive slurry grit per unit volume of water. Higher concentrations of grit per unit volume of water result in faster lapping processes. Since the abrasive grit is expensive, use standard concentrations to avoid unnecessarily higher costs for your process(es).
5. The angular velocity, or **speed or rotation**, of the lapping/polishing wheel. Higher rotational speeds result in faster lapping or polishing. Typically, choose the fastest setting of 60 RPM for your processes, but lower speeds can also be used.
6. The **temperature of the sample** being lapped or polished. Higher temperatures speed up the process. According to Lapmaster, a suggested optimal temperature for lapping/polishing silicon substrates or glass is 34 °C (93 °F), which can be achieved with heat lamps directed towards and placed above the rotating lapping/polishing wheel. Temperature is more significant than pressure (weight) for higher stock removal rates and achieving the best surface finish.
7. Additionally, **how the sticky wax is applied and uniformly pressed into place** to affix a specimen/sample to the diamond-stop fixture will affect the topography and uniformity, especially for polishing processes. For example, if uneven pressure is used to press the sample onto the fixture, some areas may become regions or valleys that are depressed and which will not be polished as quickly or as glossy as higher regions, that are in better contact with the polishing wheel.
8. To a lesser degree, the **pH of the slurry solution** affects removal rates. For example, in a higher pH solution, higher temperatures result in faster removal rates.

Terminology for the Lapmaster Machine SOP's

Abrasive Slurry Grit or Abrasive Slurry Compound	Typically, a white calcined alumina (i.e. aluminum oxide powder without heavy metal contamination) abrasive powder mixed with water. Calcined alumina powder is typically available in 1, 3, 9, 12, 15, 20, or 30 μm size "particles" or grit. A recommended mix is 4 oz. of powder added to 0.5 gal. of (tap or DI) water. The water-base vehicle may also be added to seal and protect the lapping plate from rusting during and after lapping processes..

Abrasive Slurry Pump and Agitator	This pump fits into the abrasive slurry storage tank on the right, rear of the machine, and pumps abrasive slurry compound up out of the tank into the distribution system metal tube, through the 3 adjustable feed-flow control valves, down the adjustable green wires, and onto the lapping plate.
Cerium Oxide	Added to water, this is the fastest and easiest abrasive slurry powder (approx. 2.5 - 3 µm size "particles") to use for polishing glass (SiO_2) substrates. Appearance may vary from white, red, orange, or brown, depending on the ore from which it is derived. Typically, 8 ounces of powder are mixed with 1 gallon of (either tap or DI) water.
Colloidal Silica	This polishing suspension solution, with the appearance of skim milk, is used to polish silicon wafers to a highly glossy finish. The grit particle size is typically less than 1 µm (0.125 for the Logitech brand colloidal silica polishing suspension solution). Colloidal silica may also be used to polish glass substrates, but it is not as effective as cerium oxide mixed with water.
Conditioning/Retainer Ring	These high-density, cast-iron alloy, serrated rings are used to control, adjust, and change the flatness of the cast-iron lapping plate to within manufacturer tolerances (originally measured to be less than 0.0000 inches variation across the plate) and to evenly spread the abrasive slurry grit across the plate (in ideally a single layer with the thickness of one particle) *before* or *during* lapping processes. See the *How to Check and Change the Lapping Plate Flatness* SOP for how to use these rings to change the planarity of the lapping plate. Although conditioning rings are typically not used during polishing processes, a *Micarta* ring is available to use to condition newly-installed polishing pads for polishing processes (for only the first time a pad is used after it is installed). *Do not use the metal, cast-iron-alloy conditioning rings on any polishing pads (they will wear out the pads faster than normal)!*
Diamond Stop	One of three 3-micrometer-threaded, adjustable screws in the lapping/polishing fixture used to stop a lapping process at a predetermined sample thickness. When set to an initial height using the height gauge, this screw/stop can be tightened to reduce "slop" in the screw by using the side-mounted Allen-wrench screw. Once this stop-screw contacts the lapping plate, the plate will be burnished (they are designed to neither scratch nor etch the plate) to indicate your process is finished. These stops are not effective and not used for polishing processes (if already set during a polishing process, they will simply press into the soft polishing pad and generally not damage the pad).
Diamond Stop Lapping/ Polishing Fixture	*Also referred to as the diamond-stop fixture.* This is the 8-pound fixture to which a sample to be lapped and/or polished is affixed via sticky wax and which contains three adjustable, threaded diamond-tipped screws. To stop the removal of material from a sample at a predetermined, desired thickness during a lapping process, the height of the diamond-tipped stops is set by using the height gauge, adjusting and then tightening the diamond stops with the side Allen set screws.
Digital Timer	Located on the left-most side of the front panel, this timer can be set to keep the lapping or polishing wheel spinning for a predetermined length of time between 0.1 sec. and 999 hours. This timer does not control any other machine functions (i.e. it will not shut off abrasive or polishing slurry distribution systems - **IS THIS TRUE?**). **Users are strongly encouraged to not use this timer to run the machine while it is unattended.** Users should monitor their processes on the

	Lapmaster machine at all times, in case the machine malfunctions or your process finishes earlier than anticipated.
Feed-Flow Control Valve	One of three such "infinitely variable," hand-adjustable abrasive slurry outlet valves above the machine, which is part of the abrasive slurry distribution system (including the bendable green wires down which slurry flows when it is being pumped onto the plate). Each of these valves separately controls the slurry flow rate onto the lapping plate. *These valves do not control flow rates for polishing slurries during polishing processes.*
Feeler Gauge	A thin metal strip of precise, known thickness (e.g. 5, 10, 20, 25 µm) that is used as a gauge to estimate the degree of planarity (convexity or concavity) of the lapping plate. A cheap and simple feeler gauge that may be used is a flattened and pressed aluminum candy wrapper foil, which is usually 0.0005 inches (0.5 mil, or 12.7 µm) thick. See the *How to Check and Change the Lapping Plate Flatness* SOP for techniques on how to use this gauge to check the planarity of the lapping plate.
Height Gauge	An instrument with a dial gauge indicator (in microns or mils) that is used to precisely set the desired height of the adjustable, threaded diamond-tipped screw stops (diamond stops) on the lapping/polishing fixture. This gauge should first be "zeroed" on the flat surface of the diamond-stop fixture (once at "zero," the outer black ring on the gauge can then be rotated, which will move the dial tick marks around). The diamond-tipped screw being adjusted is then brought up into contact with the height gauge shaft (it can be tightened to reduce "slop" in the screw by using the side-mounted Allen-wrench screw). The height gauge should then be moved around slightly to find where the highest points on both shafts come into contact. This is the position to use for adjusting the height of the diamond-tipped screws.
Lapping	A rough chemical-mechanical-polishing (CMP) process, where a sample (such as a metal, ceramic, plastic, glass, or silicon substrate) is machined, smoothed, and planarized to a high degree of refinement or accuracy using a rotating, serrated, cast-iron-alloy circular plate and an abrasive slurry grit in water suspension applied to the plate in a controlled fashion. Lapping relieves surface stresses on substrates.
Lapping Plate or Wheel	A high-density cast iron alloy, radially-serrated, precision-machined, highly-planar circular plate used for bulk stock removal (for course, fast removal of much material). This plate may be removed with an Allen wrench. Samples to be lapped are placed face down, wax-mounted to the diamond-stop fixture (which itself will rotate once the wheel rotation is started), and held in place over the lapping plate within a conditioning/retainer ring wedged inside a roller yoke. Since both the condition and planarity (i.e. concavity or convexity) of the lapping plate's topography will be transferred as a mirror image to the sample being lapped, it is important to properly check and adjust/correct the planarity of the lapping plate before and during a lapping process.
Micarta Conditioning Ring	*See also Conditioning/Retainer Ring, above.* A *Micarta* ring is available to use to condition newly-installed polishing pads for polishing processes (for only the first time a pad is used after it is installed) and is designed to not wear out the pads as quickly as metal conditioning rings will. *Do not use the metal, cast-iron-alloy conditioning rings on any polishing pads (they will wear out the pads faster than normal)!*
Peristaltic Pumping System	This Masterflex pump and pump head are used to force polishing slurry fluid (cerium oxide in water suspension or colloidal silica) from the glass bottles on the left side of the machine, through the flexible, rubber

	tube onto the polishing pad through the horizontal outlet port arm. The pump head (through which the rubber tube is routed) is interchangeable so that other types and sizes of tubes may be used in the system.
Polishing	A CMP process, where a sample is smoothed or burnished to a glossy, finished surface using cerium oxide powder mixed with water or colloidal silica. Polished surfaces are denser, harder, and have more intrinsic stresses than lapped surfaces. Polishing creates more friction, more drag, and higher substrate/sample temperatures than lapping processes. Polishing to a glossy surface usually starts around the outside edges of a specimen/sample and works its way inward over time.
	Either of two possible common schools-of-thought may be used to determine how much material you should seek to remove during polishing: 1. Remove a depth of material on your specimen/sample equal to at least *one-half* the abrasive-slurry grit-particle size (e.g. if 12 μm calcined alumina powder was used during lapping, remove at least 6 μm of material during polishing). 2. Remove a depth of material on your specimen/sample equal to at least *three times* the abrasive-slurry grit-particle size (e.g. if 9 μm calcined alumina powder was used during lapping, remove at least 27 μm of material during polishing). This depth of polishing is especially used to remove all material that may be within cracked valleys or cracked grooves caused by the abrasive slurry grit particles.
Polishing Pad	This is the adhesive-backed pad which is carefully applied (without bubbles) to the circular aluminum plate/wheel for polishing operations. Many different pads are commercially available. This Lapmaster system was originally shipped with a white 15-inch Suba II pad (made by Rodel) for high-production silicon-wafer polishing.
Polishing Plate, or Wheel	A 15-inch circular aluminum plate on top of which is affixed an adhesive-backed polishing pad for polishing processes.
Polishing Solution, or Polishing Suspension	*See also Cerium Oxide or Colloidal Silica.* This is a generic term referring to the abrasive slurry used during a polishing process. The typical grit size is less than 3 μm.
Roller Yoke Assembly	One of four available adjustable, nylon-roller-bearing assemblies used to hold the diamond-stop lapping/polishing fixture (and any weights placed on top), circumscribed by a conditioning/ retainer ring, in place on the lapping plate; or, to hold the diamond-stop fixture in place by itself on the polishing plate. Up to three of the black yoke assemblies may be used at one time in a lapping process (e.g. one to hold the diamond-stop fixture inside a conditioning ring and two to hold conditioning/retainer rings to change the planarity of the cast-iron lapping plate). The three black-painted yokes are used for lapping processes, and the stainless steel yoke is used for polishing processes. The special stainless steel yoke is smaller and will only hold the diamond-stop fixture in place on the rotating polishing wheel (it is not big enough to hold the diamond-stop fixture circumscribed by the diamond-stop fixture). *Do not use the metal, cast-iron-alloy conditioning rings wedged inside black yoke assemblies on any polishing pads (they will wear out the pads faster than normal)!*

Setting Fixture	This is a convenient stand and mounting block used to position and hold the diamond-stop fixture, face-up (i.e. specimen/sample side up), to use the height gauge (with dial indicator) to set and adjust the height of the diamond-stop screws prior to wax-mounting the specimen to be lapped or polished to the diamond-stop fixture.
Sticky Wax	A generic trade-name for the meltable wax, either hard and brittle or soft and malleable, used to temporarily adhere substrates to the diamond-stop lapping/polishing fixture. It melts at approx. 170 °F and is solid at room temperatures. Remove a substrate/sample that is wax-affixed by heating up the diamond-stop fixture on the hotplate and by using a chlorinated solvent. This wax is approximately 0.0002 inches (5.08 µm) thick when melted and pressed into place to affix a substrate/sample to the lapping/polishing fixture.
Straight Edge	A 15-inch-long hardened steel tool, which when properly placed on its precision-machined top edge, can be used to access the planarity of the cast-iron lapping plate.
Water-Base Vehicle	This is a generic term for Lapmaster's semi-proprietary solution that is added to lapping slurries to coat and seal the cast iron lapping wheel and prevent it from rusting (oxidizing) during and after lapping processes. Add 8 to 10 oz. of the proper lapping abrasive slurry compound per gallon of vehicle (or 2 oz. per quart of vehicle); or, add 1 part vehicle to 10 parts water.
Weights	These iron-cast-alloy, machined, 8-pound, solid-pressure disks may be stacked on top of the diamond-stop lapping/polishing fixture to add weight to a lapping or polishing process. When stacked, these work best if a non-slip pad is placed between (or affixed to one of) them to prevent sliding and "ejection" from the machine during a lapping process. Each pressure disk is equipped with a threaded hole for a lifting knob.