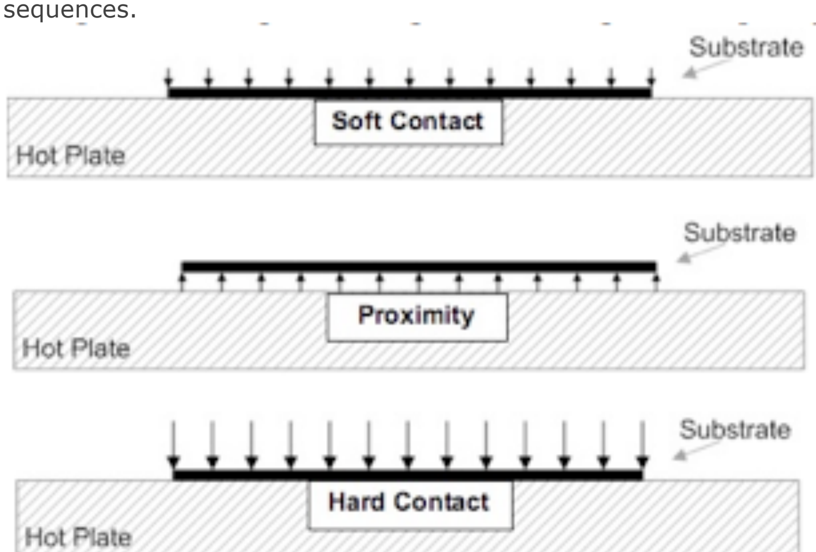
Since the dawn of the microelectronics industry, application engineers have required the ability to uniformly cure photosensitive materials. Particularly, curing wet-developable spin-applied films evenly across the substrate surface has presented a technical challenge. Such curing has become increasingly difficult with the introduction of large format substrates (200- to 300-mm) and the continual decrease in critical dimensions. Uniform baking across the substrate surface is critical to reduce over-curing, which causes "scumming," and under-baking, which causes undercut erosion and pattern collapse.

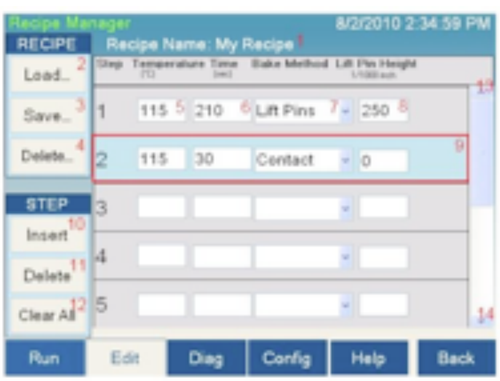
High-uniformity precision bake plates have successfully achieved the level of performance needed to overcome these hurdles. These bake plates include features such as programmable bake times and multiple bake methods (contact, proximity, and vacuum) and are capable of maintaining temperature uniformity of ± 0.3% within the active working surface.
Multiple bake methods are performed with the use of a chuck having a series of concentric hole patterns that deliver either vacuum or nitrogen proximity gas. The concentric patterns determine the active size-specific (2 inches to > 200 mm) areas for N2 gas or vacuum distribution. These ports serve a dual function by supplying N2 for proximity baking and by floating the substrate into the active process position during the loading and unloading bake recipe sequences.

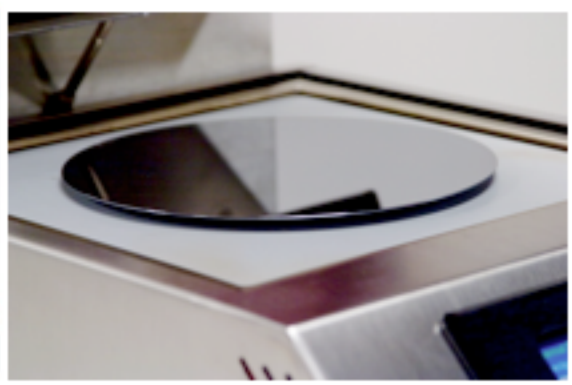


N2 Proximity Contact: In this method, the substrate is floated on a self-leveling “pillow” of nitrogen at about 0.006-0.020 inch from the bake plate surface during baking. The gradual heating of the substrate reduces the blistering and cracking of films that sometimes results from the use of fast-drying solvents. This bake method can eliminate the need for two separate bake plates with similar temperature set points (within 10°C). Proximity baking with an N2 pillow mitigates the risks associated with physical contact between the substrate and the bake plate and has been adopted for many photomask and display processing applications. The N2 gas pillow accurately aligns the substrate against the vertical centering stop pins during the loading process.

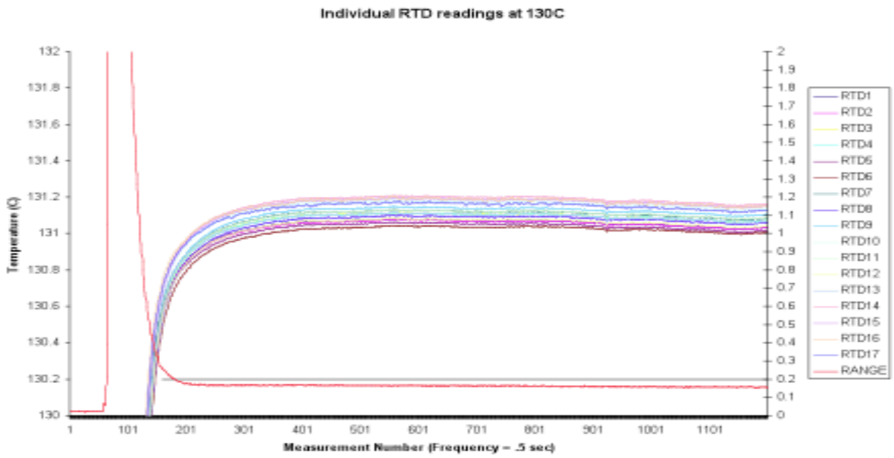
Gravity Soft Contact: In this method, the substrate is held against the surface of the chuck by gravity. This style provides an intermediate method between hard vacuum contact and proximity bakes where a controlled multiple-step set point acceleration ramp is required. This style is very flexible and is compatible with any substrate size within the working surface area of the bake plate (1 inch from the surface plate perimeter).

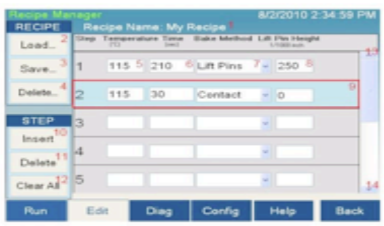
Hard Vacuum Contact: This method is the most accurate baking method for bake plates and uses vacuum ports to ensure intimate contact between the substrate and the bake plate. This style ensures baking uniformity and minimizes warping and/or bowing of the substrate. Additionally, a bake plate should maintain minimal variation from the temperature set point during loading and unloading of a substrate. This objective can be achieved by utilizing a large thermal mass in the bake plate surface. Although critically important to minimizing temperature variation, this large mass typically limits the speed of the set point acceleration. Multiple bake plates are generally utilized for spanning large ranges of set point temperatures. Brewer Science® Cee® bake plates equipped with programmable ramping temperature controllers and compatible software can give a single bake plate the ability to ramp from low to high temperatures with precise soak times and up to ten incremental temperature step changes. This feature is limited to temperature increases up to about 50°C, and requires significant cooling times between bake recipes.
Brewer Science® Cee® bake plates incorporate a sophisticated technology that can address this handicap by utilizing program-controlled electronic lift-pins. This option utilizes accurate stepper motor control (±0.002 inch) that will drive the lift-pins to 100 specific proximity process heights above the baking surface in any sequence or combination. The heights are programmed in 0.001-inch increments, with an overall operating window from 0.001 inch through 0.750 inch. Traditionally, this technology was only available on million-dollar track equipment. Recently, this capability has been adapted to a compact benchtop version that is intended specifically for prototype-scale production. This flexible feature enables faster ramping acceleration/deceleration and emulates several bake plate temperatures simultaneously, while maintaining a high degree of bake uniformity. This feature is extremely valuable for the safe handling of thermomechanical shock-sensitive materials such as gallium arsenide, lithium niobate, indium phosphide, gallium nitride, silicon carbide, and sapphire substrates.

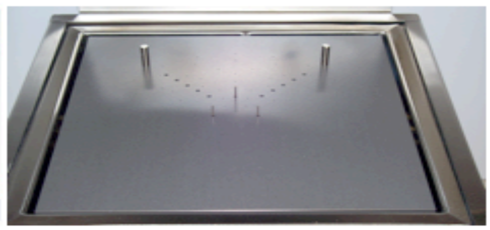




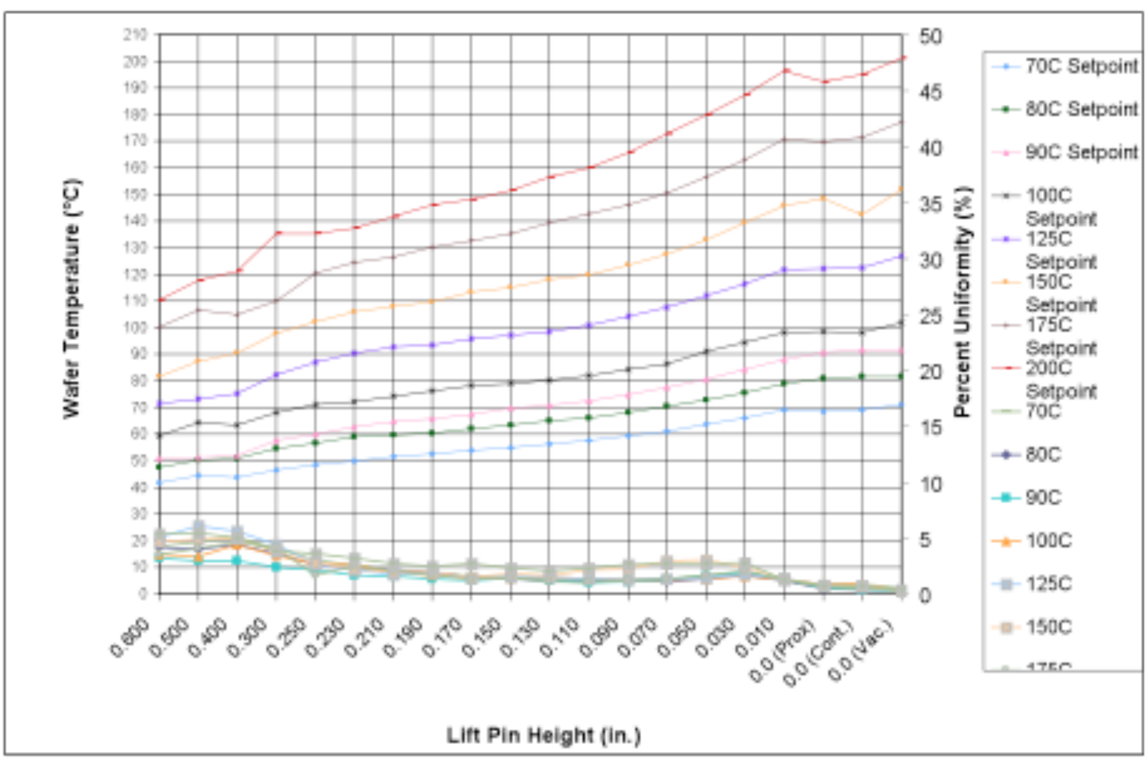
Brewer Science® Cee® equipment engineers have utilized the KLA-Tencor® SensArray measurement probe to measure, track, and record temperature conditions produced by Cee® bake plates. The engineers have meticulously performed these process trials and developed user-friendly temperature matrixes for a variety of common temperatures used for a soft bake (100°C), post-exposure bake (PEB), and post-develop hard bake (205°C) for final curing.







The following chart represents a temperature matrix reflecting a surface temperature of 200°C, and incremental descent from 0.600 inch to hard vacuum contact in downward steps in increments of 0.100-0.020 inch. Each positional height is allowed to stabilize for a period of 300 seconds (5 minutes), and uniformity is recorded at these heights.



By eliminating the need for multiple bake plates, this programmable system is a cost-effective option in a space-saving design. This configuration is ideal for performing multiple set points (dual stage), baking "from the inside out" for thick-film materials such as MicroChem SU-8 materials, MicroChem KMPR® materials, Shipley BPR™-100 photoresist, and Brewer Science® WaferBOND® HT-10.10 materials, and mitigating concerns associated with the "skinning" effect.

The Brewer Science® Cee® high-uniformity bake plate product family brings together all these capabilities in a compact footprint designed for a lab-scale environment.