# MICROPERFORATIONS FOR FRESH CUT PRODUCE PACKAGING

By Christopher Chow, *Preco Laser Systems, LLC*

[i]The NPD Group, a marketing research firm, recently reported that for the first time in six years American's eating habits are moving in a new direction. After gaining weight years after years since 1998, Americans lost weight in the last year and are eating healthier. They are eating 6% more fresh fruit and 5% more vegetables than they ate the year before. Consumer behavior and demographic trends are sending clear signals that the demand for convenience and value added produce are continuing on the rise. Supermarkets and grocery stores are responding by increasing the floor space for a variety of fresh fruits and vegetables that are washed, pre-cut, sliced and packaged. Restaurants and even school lunches are enlarging the selections for fresh fruits and salads. As for packaging suppliers, the opportunities become abundant to provide effective packaging processes that maintain the quality and taste of the produce with an extended shelf life for consumers and eatery operations alike. Although few people outside the industry realize it, the trend towards pre-cut produce has drastically changed the nature of the produce industry.

It is well known in the produce industry that controlling the storage temperature and modifying the atmospheric conditions within the package are the two most important factors to maintain freshness and extend the shelf life of the produce products. The two act together to slow the metabolism and aging of the product. By correctly manipulating the amount of oxygen, carbon dioxide and moisture within the packaging at the appropriate storage temperature, the modified atmospheric packaging enables the produce to live longer by delaying respiration, ripening and ethylene production.

Several techniques have been used to change the atmosphere of the fresh cut packages. Various sorbent, in the form such as sachets, tablets or laminated film, could be incorporated into the packages to absorb the undesirable components of the gaseous species. The method, however, has not been popular because they represent added components to the packages and are subject to consumer misuse. A more popular approach is the use of custom blended polymeric monolayer and/or co-extruded film specifically engineered to provide the right amount of oxygen transmission. These bags have been proven to be useful to prolong shelf life. However, different fruits and vegetables, and even different varieties of a given fruit or vegetable have different respiration rates. Therefore, bags with different oxygen permeability are required. As the fresh cut produce industry grows more sophisticated, so too is the sophistication of the packages with constant changes in attractive printing, antifog coating, etc., all of which potentially affect the permeability of the bag. One can imagine the logistic nightmare facing packaging processors as the variety of products increase and the demand for promotional changes becomes more often. Simply put, an urgent need exists for the packaging processor to have a flexible atmosphere modification method that allows them to minimize the inventory of film stocks, yet maximize the flexibility to provide the right type of atmospheric conditions at the late processing stage based on the type of product to be bagged, taking into account the physiological condition during harvest and the final mix and match of the produce. This is why microperforation, whereby small microscopic holes are made on the film long after printing and during the film converting process, becomes such an attractive method.

Consistency of micro holes are very important, particularly for fresh fruit applications. Table 1 shows an example of an application where there is a limited packaging surface area for gas transmission such as in plastic containers with a lid made from flexible film.  Examples of two fresh fruit are shown:  Melon, having a requirement for higher oxygen transmission rate vs. citrus.  Because of the limited lid surface area, the highly permeable polyethylene film would only give an OTR value of 254 which is too small for the required OTR value.  However, with the perforation of either four or two holes, respectively, for the two containers, the OTR value is closely achievable.  Because of the limited number of perforations that are required, the accuracy of those holes become of utmost importance for retaining the freshness of the fruit while avoiding anaerobic condition .

**Table 1.  Microperforation On Lid For Fresh Fruit Container**

| **Fresh Fruit Lid Perforation** | | |
|---|---|---|
| Product | 6 oz. Melon | 6 oz. Citrus |
| Container ID (in) | 4 | 4 |
| Lid Area (in$^2$) | 12.6 | 12.6 |
| OTR Required | 1000 | 320 |
| OTR for 2 mil permeable PE | 254 | 254 |
| OTR on lid without perf | 29 | 29 |
| # of perfs on lid (4 mil hole) | 4 | 2 |
| OTR on lid with perf | 958 | 314 |

OTR is measured in cc/100 sq. in./24 hours at 75°F, 0% R.H.

Micro perforation can be achieved in a number of ways.  Mechanical needle perforation has been practiced for some time.  Small needles on a fabricated drum pushes holes on the film as it is being converted and rewound.  These needles can be applied with or without heat.  The processing for hot needle operation is slow.  The hole size tends to be big and visibly noticeable.  Cold needle perforation punches the film without removing the film material.  The partially torn material collapses back onto the hole and consequently results in very inconsistent hole.  Perforations can also be obtained by electrostatic discharge.  A packaging film is passed through high electrostatic voltage.  Sparks are generated through the film, causing micro holes.  The electrostatic process is slow and only works for thinner polymer materials.  The arcing process is also hard to control, making it difficult to obtain the desirable number of holes or the desirable flow rate.

Laser perforation is the newer method to provide micro holes. For industrial lasers, such as $CO_2$ lasers, the intensity of the light is readily absorbed by the polymeric film. The film is heated, melted and instantaneously vaporized, leaving a very small well defined hole on the film. As the laser pulses, holes can be made to obtain the desirable number per unit length as the web advances. Depending on the laser intensity, different hole sizes can be obtained. Typically, the laser operation can be mounted onto the rewinder as part of the film converting operation. By altering the size and density of the micro hole, packaging film with a specific flow rate can be adjusted for a specific produce product. When the harvest condition is changed resulting in a different physiological stress for the cut produce, the laser equipment can be adjusted to meet the new requirements on hole size and hole density.

Standard $CO_2$ lasers operate well for speeds up to 300' per minute. Beyond that speed, laser holes become oblong and the hole consistency drastically reduces. This is due to the fact that as the web position moves at a rate as a significant fraction of the time required for the laser pulse, the laser energy is spread on the film resulting in the oblong holes. A much bigger problem is that as the laser energy per unit area reduces, the holes might be only partially perforated or not perforated at all, rendering unacceptable materials for produce packaging.

Preco Laser Systems (PLS) recently introduced a beam compression technique that allows laser microperforations to be run at 1000' per minute and beyond. Beam compression refers to a patented technology whereby the laser pulse is manipulated and guided to direct all its energy to a single point on the film. Because the energy received per spot is independent of the web speed, the resulting micro holes are always round and the flow rate is consistent. Fig. 1 shows the flow rate as a function of relative laser energy for the beam compression perforation system of Preco Laser Systems. The web speed was at 1000' per minute. The flow rate was measured in standard cubic centimeters per minute under 1 atmospheric pressure. Please note the range of the standard deviation which is unsurpassed by any other microperforation technique.

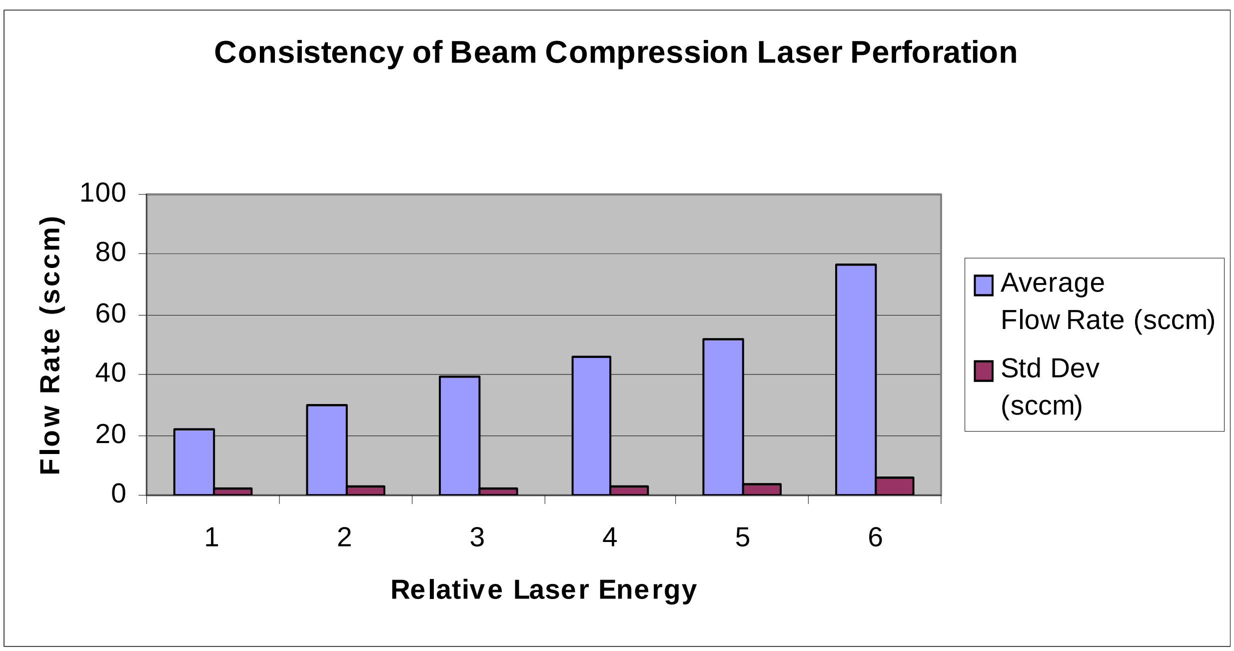

Fig. 1 Flow rate as a function of relative laser energy for the Beam Compression Laser Perforation from Preco Laser Systems. Web speed was at 1000 ft/min. Flow rate was measured in standard cubic centimeter per minute under 1 atmospheric pressure.

Fig. 2 shows a typical example of flow rate vs. hole diameter for a 2.5 mil laminated film. This result is experimentally determined. It tends to depend on the thickness of the film as well as on the specific film composition.

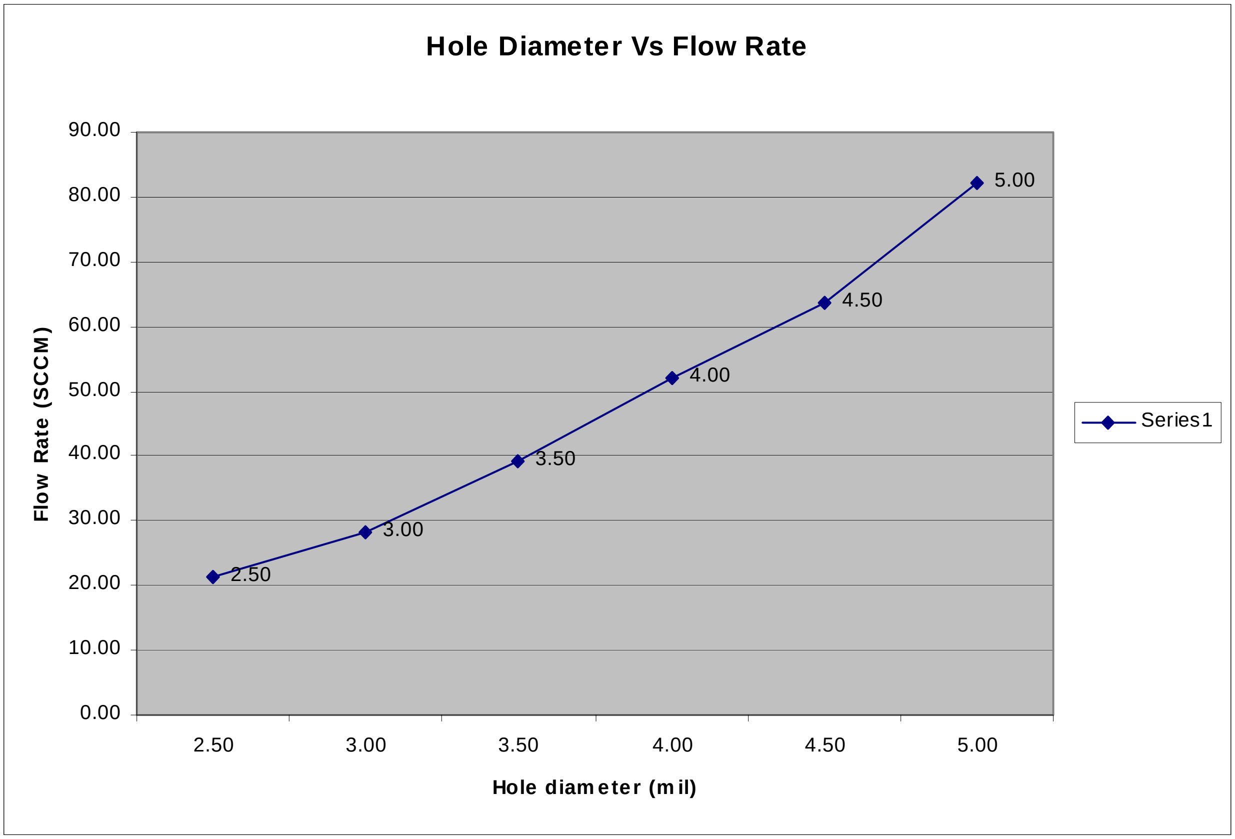


Fig. 2 Flow rate as a function hole diameter for a 2.5 mil film laminate

Fig. 3 shows pictures of micro perforated holes obtained with and without beam compression.  As a result of the unique process of beam compression in retaining the roundness of the hole independent of processing speed, useful product from beginning operation to the end including ramp-up and ramp-down can be obtained.

**With beam compression**

**Without beam compression**

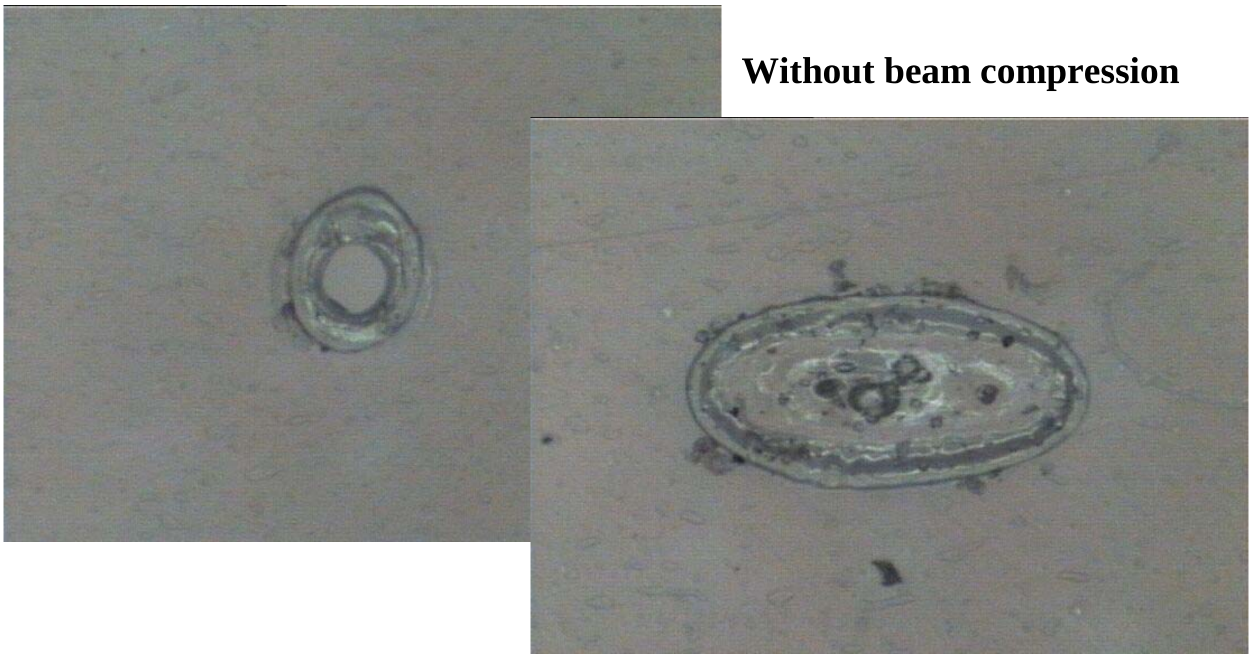

Fig. 3  Comparison of micro perforating holes with and without beam compression.  Diameter of the round hole is about 3 mil. in diameter.  Perforations performed at 1000 feet per minute

Fig. 4 shows the consistency of laser micro perforation during the ramp-up, steady state and the ramp down operation. Note that the steady state web speed for the beam compression operation was at 1000’/minute, whereas the steady-state web speed for the non-beam compression was at 500’/minute.

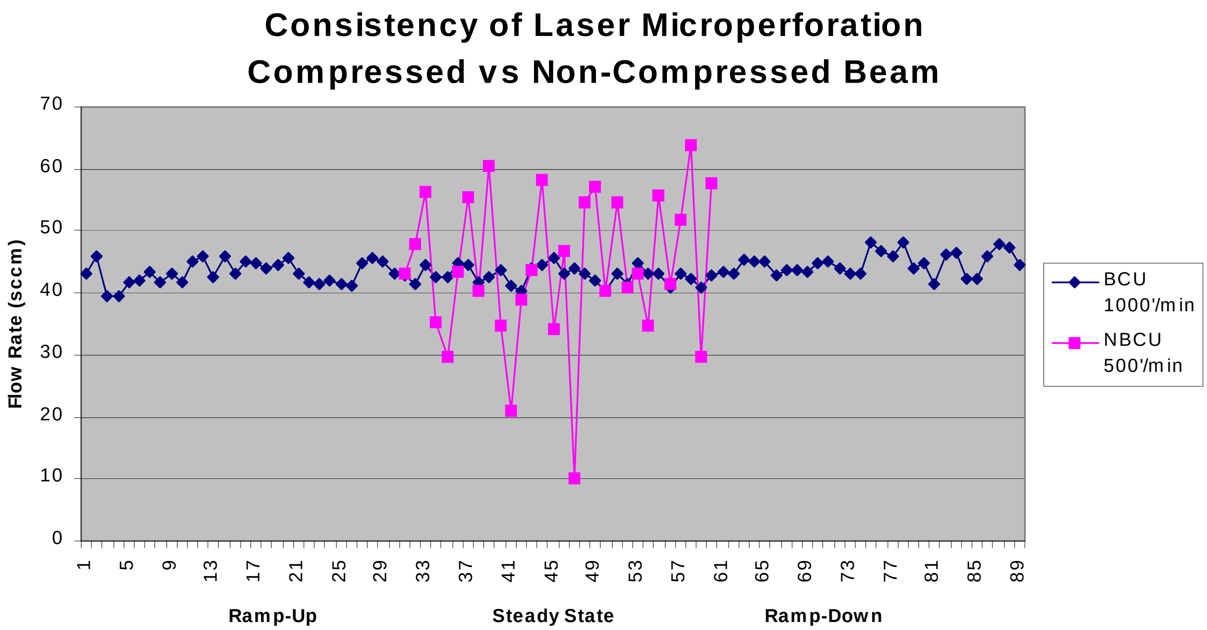


Fig. 4 Consistency of laser micro perforation during the ramp-up, steady-state and ramp-down operation during the converting process. Steady-state web speed was a 1000 ft./min.

Furthermore, beam compression technology allows the efficient use of laser pulses of 300 microseconds or longer. The effectiveness of beam compression technology allows laser perforation to be performed at 1000' ft./min. on a typical 2-3 mil film with only 50 watts of laser power per lane. This reduces the equipment cost and the operating cost.

In summary, laser perforation for fresh cut produce packaging has come of age. The key factors for the successful implementation such as flexibility, consistency and productivity have all been achieved. Laser equipment, such as the beam compression system from Preco Laser Systems are now commercially available. For further information and questions, please e-mail Christopher Chow at cchow@precolaser.com or visit our web site at www.precolaser.com or call directly to Chris Chow at 800-77-LASER x1179.

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[i] *NPD Group, 18th Annual Eating Patterns in America, NPD Press Release, October 14, 2003, http://www.npd.com/press/releases/press_031014.htm.