Microwave Susceptors

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Extended Abstract

History

In today's food preparation it is hard to imagine not having a microwave oven in one's kitchen. From the reheating of leftovers to the heating of a complete meal taking only minutes from frozen to hot state it has added tremendous convenience to today's life style. Looking back though, it is not that long ago that the microwave oven has become a staple of the modern kitchen. In fact the first microwave oven was introduced 60 years ago in 1947, and it is only 40 years, in 1967, that the first microwave appliance was presented.

The development of the microwave oven started in the last year of World War II, when Laurence Marshal, owner of the Raytheon Corporation, tasked his engineers to find new applications for the high frequency magnetrons that Raytheon builds to supply the military with radar equipment. At that time the heating effect of high frequency electromagnetic fields was known already, so one of the logical conclusions was to build a high frequency range for heating materials. Originally food stuff was not in the center of this thought, rather the heating of process materials.

It is not sure whether the famous "Hershey Bar Incident", in which Percy Spencer, chief developer at Raytheon allegedly realized that a chocolate bar in his lab coat melted when he passed a running magnetron, has taken place, but if so it may have indeed steered the application of the microwave oven towards the heating of food.

In the typical manner of engineers building military equipment the first microwave oven was totally over engineered: it weighed in at more than 300 kg., was about 1.6 m tall and had to be water cooled – certainly not a household appliance. It was so powerful that it popped a full cob of corn within 20 seconds, and a potato was cooked in less than a minute. The price tag was enormous too: US-$ 2,000, which equals about US-$ 20,000 in today's value.

Even though some of these ranges, including a slightly smaller model that was developed afterwards, sold to large restaurants and institutions, it required the acquisition of the appliance company Amana as well as the introduction of a cheap magnetron from Japan

that a microwave appliance could be offered that was affordable and that would provide the convenience that is known today. In 1967 the first Amana Radar Range – the name being reminiscent to the root of the magnetron's first larger application – was presented to the public, and with an enormous marketing effort the sales of these instruments took off. In 1975 the sales of Microwave Ovens surpassed the sales of gas ranges, and today more than 95% of the American households have at least one microwave oven at their disposal.

Microwave Susceptors

Even in the early development stages of the microwave oven it became clear that the microwave was capable of heating the bulk of foodstuff at a high rate, but that it would not provide browning or crisping of the outside of the food. This however is essential to the texture and the sensation of many food products, particularly starchy and dough products such as french fries or pizzas. The main reason for this is that the high frequency electromagnetic field is absorbed in the bulk of the food, but not on the surface, unlike infrared radiation which is absorbed on the surface only. Because of that the drying and crisping of the food surface does not take place. Early on additional devices such as infrared lamps were added to the ranges, so that some browning and crisping could be achieved.

Shortly after the introduction of the Amana Radar Range devices were presented that absorb part of the microwave energy and turn it into heat that, when in direct touch with the food product, would provide the browning and crisping. In 1978 W. Brastad introduced the concept of a polyester film metallized with a very thin layer of aluminum, laminated to a support structure. This type of film, depending on the optical density, partially absorbs the microwave energy and turns it into heat. Today, almost all microwave susceptors are based on this concept. Since the optical density of the metallization on these materials is typically in the range of 0.20 to 0.30, the laminate has a specific gray appearance. In this range of optical density the surface resistance if the aluminum is high enough to limit the currents generated in the metallic layer, thus preventing arcing that would occur if currents become too high. The induced currents are high enough, however, that a heating effect takes place.

Today basically all microwave susceptors used in food packaging are based on this material, and they can be found in numerous applications.

Patterned Susceptors

A uniform susceptor like the one described above is not desired in all of the applications, be it that certain areas need more energy to penetrate into the bulk than being absorbed at the surface, or be it that some areas need no susceptor at all. Patterned susceptors can offer advantages in these cases. Patterning is achieved either by removing parts of the susceptor through etching of the aluminum surface, or by selective deposition of the

aluminum on the carrier material. With patterning it is now possible to provide surface heat were needed, guide microwave energy to areas that need more heating than other areas or provide more uniform heating across the whole food package, particularly in cases where the microwave oven may provide non-uniform heating in the first place.

Patterning also provides additional functions such as the usage of “Safety Susceptors”, employing a fuse type pattern that shuts down areas of the susceptor if the currents in these areas increase too much. This prevents overheating of the package. Another function of a patterned susceptor is the possibility to induce “Grill Stripes” onto the food, mimicking the usage of a grill to heat and crisp the food stuff.

The Future

Usage of Microwave Susceptors in food packaging continues to grow at a large pace. This is mostly to the increasing convenience that pre-cooked meals offer to a civilization that spends less and less time on the preparation of meals.

Challenges for the application of susceptors is to find ways to further improve on the convenience of food heating in the microwave, be it that the food cooks even faster, or that a complete meal including appetizer, entrée and dessert can be cooked in the microwave in one package, achieving different temperatures for all three of the different parts of the meal.

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