

## GAS DISCHARGE LAMPS USED FOR PET MORPHOLOGICAL CHANGES

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**ABSTRACT:** Poly Ethylene Terephthalate (PET) was modified by gas discharge lamps in order to change the physical properties of the material without affecting its bulk features. Paper presents studies on surface modification of PET by gas discharge lamps irradiation. The morphological changes in the resulting samples were imaged and studied using scanning electronic microscope (SEM). Changes in surface morphology and surface energy of PET films were found in relation to number of irradiation pulses applied, distance between radiation source and the surface and the irradiation intensity.

**KEY WORDS:** gas discharge lamp, Poly Ethylene Terephthalate, surface morphology.

### 1. INTRODUCTION

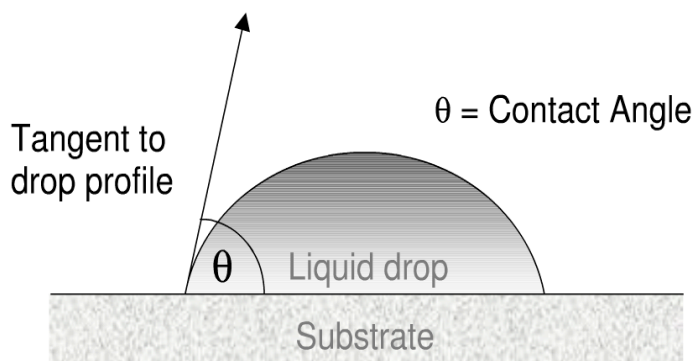
It has been known that materials like polymers, woods, metals, semiconductors, dielectrics, quartz modified by UV laser are often accompanied by physical as well as chemical changes of the materials surface. In case of polymer, some well oriented structures of hills and grooves or ripple structures in the range of micron are developed on the surface with irradiation fluency above the so-called ablation threshold e.g. PET irradiated by 248nm = 30mJ/cm<sup>2</sup> [1].

These induced structures show some interesting characteristics. For example, they are strictly perpendicular to the stress direction of the materials and strongly influenced by laser wavelength and energies, absorption coefficient etc [2-3].

The absorption coefficient of the polymer to the gas discharge lamp energy is extremely high so the value of the ablation is relatively high too. These induced structures could increase the value of polymer such as better adhesion and dyeability [4].

### 2. MEASURING THE CONTACT ANGLE

The contact angle  $\theta$  provides the measure of the ability of a fluid to cover a surface (wettability). As it is presented in figure 1 this is the angle formed between the wetted solid surface and the tangent to the wetting liquid surface (to the meniscus of the wetting liquid), at the contact point of the liquid and the solid surface. Wettability of solids by liquids varies with both surface tension and surface free energy. [4]



**Figure 1.** Contact angle analysis

There are a number of methods for measuring the contact angle, and the most common include such techniques as: the bubble measure method, geometric method (where the contact angle is measured from the dimensions of the drop), the capillary rise method (such as Wilhelmy plate method) or the direct measurement method [4].

At present, this is the direct measurement of the contact angle which is a commonly applied method, and the measurement is conducted by means of specialised instruments called goniometers or contact angle analysers.

### 3. CASE STUDY

By gas discharge lamps treatment of PET surfaces morphological changes has occurs such as lower oxygen content and carbon atoms release.

This transformations can be achieved at the irradiation level higher than 5J/cm<sup>2</sup> and surface morphology nanocraters appears as a result of carbon atoms releasing and surface oxidation.

Changes in surface morphology and surface energy of PET films were imaged and studied using atomic force microscopy (AFM) and scanning electronic microscopy (SEM) as presented below in figure 2.

The absorption coefficient of the polymer to the gas discharge lamp energy is extremely high so the value of the ablation is relative high too.

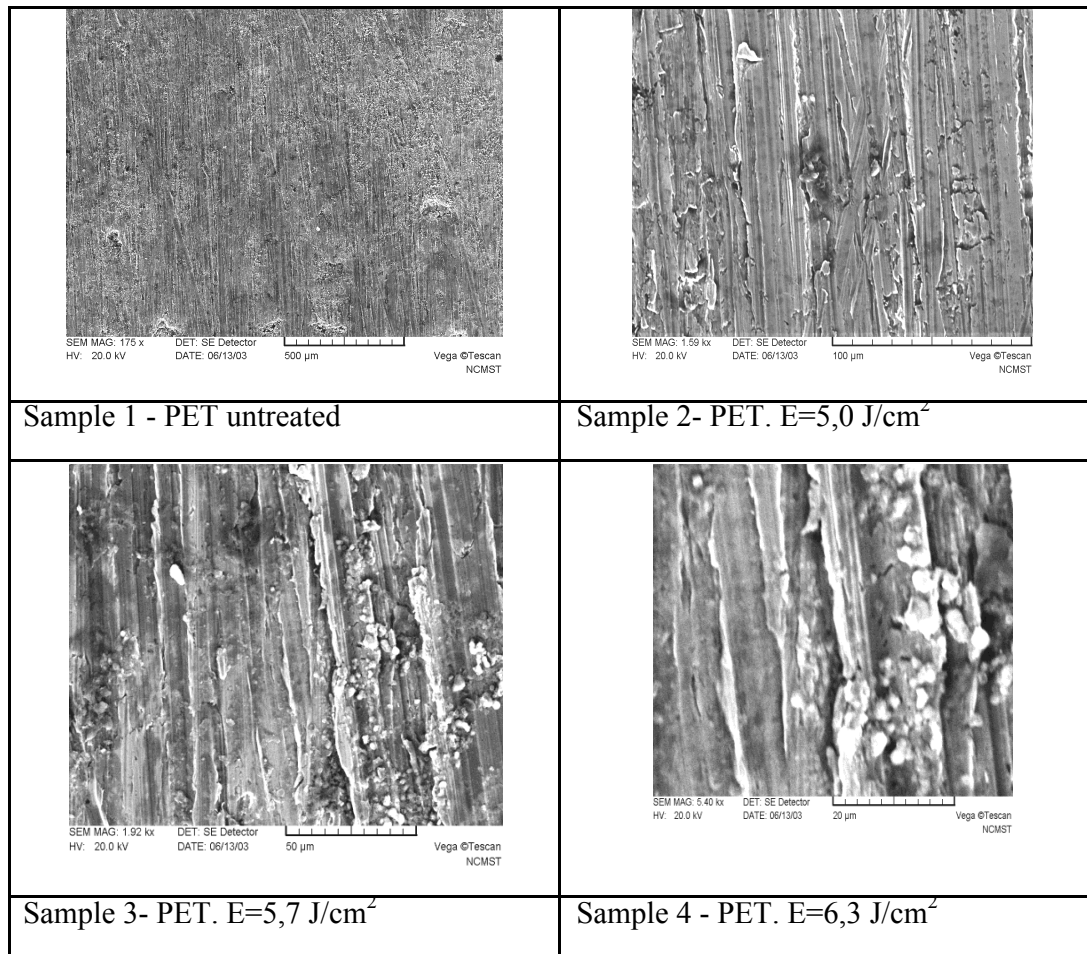


Figure 2. Research samples

The results showed that the polymer surface developed a certain amount of granular and ripple like structures after radiation exposure. The formation of these structures is believed to be the effect of the “synergetic phenomena”. The researchers interpreted this phenomenon as a “frozen-in Marangoni convection” in very thin molten layer of the polymer the effect is driven by buoyancy forces due to the thermal gradient or by local variations of the surface tension of fluid [4].

As can be seen from figure 3 ripple spacing shows a positive relation with the number of pulses. The ripples increase in size and the space between them is largely due to merging of ripples.

As it is presented in the figure 3, contact angle decreases exponentially as increasing the intensity of incident energy. PET surface sterilized at a higher energy than 5 J/cm<sup>2</sup> becomes hydrophilic.

For the PET’s bottles used in food industry (figure 4) it is recommended to fulfill the bottle immediately after the surface sterilization occurred.

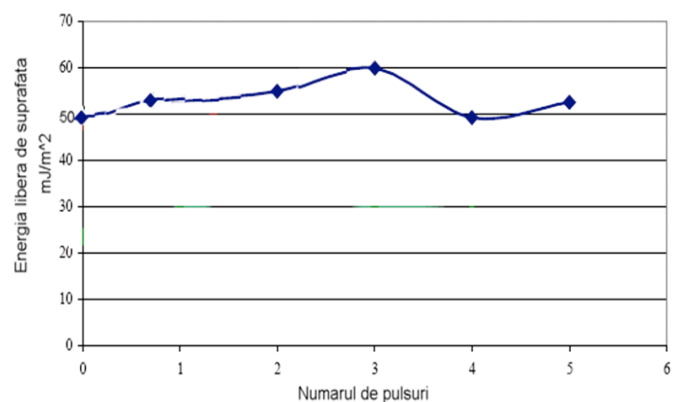


Figure 3. Free surface energy / pulse numbers

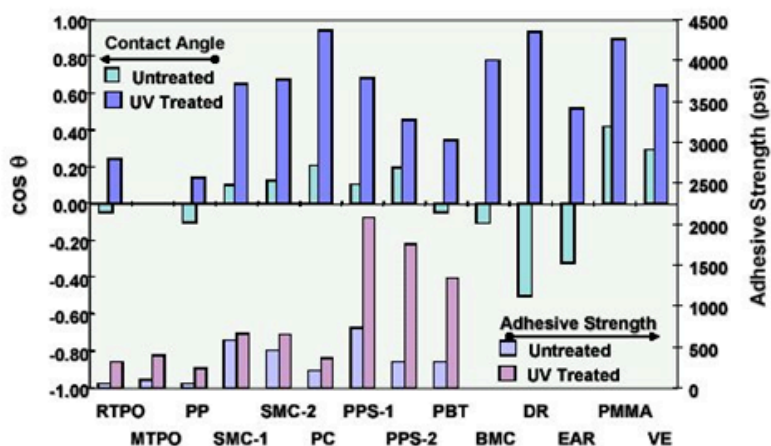
Studies were performed as irradiating the bottle from outside too, and the results reveals that it is necessary to increase the irradiation intensity to

obtain the same effects as from inner side but in this case the risk of recontamination does not occurs.



Figure 4. PET bottle irradiated from inside

The large amount of polymers types that can be treated via gas discharge lamp irradiation techniques and good results presented above indicate that this method can be applied to many other types of polymers and polymer products.



- Thermoplastic polyolefin (TPO)
  - ↳ Reactor Grade (RTPO)
  - ↳ Mechanical grade (MTPO)
- Sheet molding compound (SMC)
  - ↳ Regular (SMC1)
  - ↳ Toughened (SMC2)
- Polyphenylene Sulphide (PPS)
  - ↳ White (PPS1)
  - ↳ Black (PPS2)
- Polypropylene (PP)
- Polybutylene terephthalate (PBT)
- Bulk Molding Compound (BMC)
- Diene rubber (DR)
- Ethylene Acrylic Rubber (EAR)
- Polymethyl methacrylate (PMMA)
- Vinyl Ester (VE)
- Polycarbonate (PC)
- Bexloy (Ionomer) Composite

Figure 5. Property modification polymer treated with UV radiation [4]

#### 4. CONCLUSIONS

Gas discharge lamps induce chemical and physical surface ablation. Especially for PET, a decrease in the O/C atomic ratio and an increased hydrophobicity were detected by SEM and contact angle measurements respectively. Moreover, the layer modified with gas discharge lamp is amorphous.

A variety of topographical structures were also observed on gas discharge lamp irradiated PET surfaces. In the order of increasing fluence, the structures appearing are:

1. Dendrites, developing after irradiation (sample 2).
2. Static Structure in the form of longitudinal waves (sample 3, 4) which appear only upon irradiation of stretched polymers. The orientation of the Structure is perpendicular to the stretching direction.

#### 5. REFERENCES

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