

El-Aayah

أعوذ بالله السميع العليم من الشيطان الرجيم

بسم الله الرحمن الرحيم

إِنَّ فِي خَلْقِ السَّمَاوَاتِ وَالْأَرْضِ وَاخْتِلَافِ اللَّيْلِ
وَالنَّهَارِ لَآيَاتٍ لِّأُولِي الْأَلْبَابِ ﴿190﴾ الَّذِينَ
يَذْكُرُونَ اللَّهَ قِيَامًا وَقُعُودًا وَعَلَىٰ جُنُوبِهِمْ
وَيَتَفَكَّرُونَ فِي خَلْقِ السَّمَاوَاتِ وَالْأَرْضِ رَبَّنَا مَا
خَلَقْتَ هَذَا بَاطِلًا سُبْحَانَكَ فَقِنَا عَذَابَ النَّارِ ﴿
191﴾ رَبَّنَا إِنَّكَ مَن تَدْخِلُ النَّارَ فَقَدْ أَخْرَجْتَهُ وَمَا
لِلظَّالِمِينَ مِن أَنْصَارٍ رَبَّنَا إِنَّنا سَمِعْنَا مُنَادِيًا
يُنَادِي لِلإِيمَانِ أَنْ آمِنُوا بِرَبِّكُمْ فَآمَنَّا ﴿192﴾ رَبَّنَا
فَاغْفِرْ لَنَا ذُنُوبَنَا وَكَفِّرْ عَنَّا سَيِّئَاتِنَا وَتَوَفَّنَا مَعَ
الْأَبْرَارِ ﴿193﴾ رَبَّنَا وَآتِنَا مَا وَعَدْتَنَا عَلَىٰ رُسُلِكَ
وَلَا تُخْزِنَا يَوْمَ الْقِيَامَةِ إِنَّكَ لَا تُخْلِفُ الْمِيعَادَ ﴿
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Abstract

This study covers two case studies of optimizing surface modification in polymethyl methacrylate to be used as diffraction grating as well as improving efficiency in Silicon photovoltaic cell.

The first aim of this work is to obtain a textured surface in Poly methylmethacrylate (PMMA), and in Silicon photovoltaic cell by means of laser direct writing machine. The second aim is the characterization of the induced surface texturing by means of Scanning electron microscopy (SEM), Raman mapping, Diffraction patterns achievement and Silicon photovoltaic's Spectral Response Measurement.

In this study, a laser direct writing technique has been utilized to produce photo-thermal and optical density changes in polymethyl methacrylate surface by means of IR continuous laser and to produce micro / nano surface texture in Silicon photovoltaic cell by means of UV femtosecond laser at 180 fs, 400 nm, at 1 kHz repetition rate.

The experimental evidence of the effect of femtosecond laser pulses on the spectral response of a Silicon photovoltaic cell is demonstrated

and investigated. The response of this device covered the visible to near infrared spectral region.

It was found that the usage of IR laser radiation (810 nm) with 0.3 Watt power was sufficient to cause significant surface damage on polymethyl methacrylate PMMA.

SEM results showed formation of almost flat cracks (fissures) in PMMA sample, Raman mapping showed variations in the intensity of background scattering light in the structure of PMMA sample, no shift in Raman peaks and no new peaks appeared after irradiation process. Optical density changes caused by thermal and stress effects and plastic deformation products rather than photochemical changes may be thereby also related to refractive index modification.

Laser texturing makes it possible to increase absorption of the incident solar radiation, this texturing technique produce micro/nano surface textures in Silicon photovoltaic cell by means of UV femtosecond laser pulses. The responsivity of the photovoltaic cell was increased up to 0.25A/W.

In conclusions, the results summarized above showed that laser direct writing technique is fast and easy to produce PMMA diffraction grating as well as high quality Silicon photovoltaic cells.

This mechanism is strongly dependant on the optical properties of the material and is recommended to be studied experimentally and theoretically in the future.

المستخلص

يغطي هذا العمل دراسة حالتين الأولى لتحسين التعديلات السطحية لعينة من البولي ميثايل ميثاكريلات لغرض استخدامه كمحزوز حيود والأخرى عن تحسين الكفاءة في الخلية الضوئية السليكونية.

الهدف الأهل من هذا العمل هو الحصول على سطح معطل بالليزر في كل من البولي ميثايل ميثاكريلات (PMMA)، والخلية الضوئية السليكونية عن طريق منظومة (الكتابة) المباشرة بالليزر. والهدف الثاني هو فحص التركيب السطحي الناتج بواسطة المجهر الإلكتروني الملسح (SEM)، مطيافية رامان، الحصول على نمط الحيود وقيلست الإستجابة الطيفية للخلية الضوئية السليكونية.

في هذه الدراسة، تم استخدام منظومة (الكتابة) المباشرة بالليزر للحصول على تعيرات حرارية ضوئية وتعيرات في الكثافة البصرية في سطح البولي ميثايل ميثاكريلات بليزر الثنائي بنمط مستمر وكذلك للحصول على زخرفة سطحية مايكرونية/نانوية على الخلية الضوئية السليكونية بليزر نضي بزمن نبضة 180 فيمتوثانية، وطول موجي 400 نانومتر و بمعدل تكرار 1 كيلو هرتز.

أوضحت النتائج التجريبية تأثير نضلت الليزر بالفيتمو ثانية على الإستجابة الطيفية للخلية الضوئية السليكونية حيث أن إستجابة هذه الخلية تغطي المنطقة الطيفية المرئية والأشعة تحت الحمراء القريبة.

وجد أن استخدام أشعة ليزر الثنائي تحت الحمراء (810 نانومتر) بقدرة 0.3 واط، كان كافياً لعمل التعغيرات على سطح البوليمر PMMA.

أظهرت نتائج جهاز المجهر الإلكتروني الملسح تكوّن بعض الصدعت في عينة البوليمر. وأظهرت نتائج جهاز رامان وجود اختلافات في شدة تشتت الخلفية الضوئية من تركيب عينة البوليمر PMMA ولم يتغير موقع أي قمة في طيف

رأمن ولم تظهر أي قمم جديدة بعد التشعيع. وجد أن هناك تغيرات في الوزن الجزيئي وفي الكثافة الضوئية ناجمة عن التأثيرات الحرارية والإجهاد، وتشوه بلاستيكي كلها تغيرت نتجت بطلاً من التغييرات الكيميائية الضوئية وهي تتعلق بتغيير معامل الانكسار.

حفر السطح بالليزر جعلت من الممكن زيادة لمصطى الإشعة الشمسية الساقطة، تُنتج هذه التقنية تركيب نانوي/مايكروني في سطح الخلية الضوئية السيليكونية باستخدام التشعيع بليزر الأشعة فوق البنفسجية النبضي بالقيمتو ثانية. وجد أن استجابة هذه الخلية الضوئية تصل الى $A / W 0.25$.

إن النتائج أعلاه تبين أن تقنية النقش بالليزر عبارة عن تقنية سهلة وسريعة للحصول على مجزوز حيود بوليمري وكذلك للحصول على خلايا ضوئية عالية الجودة.

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List of Abbreviations

3-D	Three Dimensions
AFM	Atomic-force microscopy
APS	Air Plasma Sprayed
BBO	Beta Barium Borate
CARS	Coherent Anti-Stokes Raman
CCD	Charge-Coupled Devices
CW	Continuous-wave
DSC	Differential scanning calorimetry
E_{bg}	band gap
EDS	Energy-dispersive X-ray Spectroscopy
E_F	Fermi energy
fs	Femtosecond
HAZ	heat affected zone
IR	infra-red
LDPE	low density polyethylene

LDW	Laser Direct Writing
LDW-laser	direct write subtraction
LDW+	laser direct-write addition
LDWM	laser direct-write modification
LIBWE	laser-induced backside wet etching
LIFT	laser induced forward transfer
LiNbO ₃	Lithium Niobate
LO	longitudinal-optical
ND	natural density
Nd:YAG	neodymium-doped yttrium aluminium garnet; Nd:Y ₃ Al ₅ O ₁₂
NIR	near infrared
PDA	Photodiode Arrays
PDMS	poly dimethyl siloxane
PDMS	Poly dimethylsiloxane
PMA	poly(methyl acrylate)
PMMA	poly(methyl methacrylate)
PMT	Photomultiplier Tubes
POF	polymer optical fibre
ps	picosecond
PS	polystyrene
PVA	poly vinylalcohol
RR	Resonance Raman
SEM	scanning Electron Microscopy
SERRS	Surface-Enhanced Raman Resonance Spectroscopy
SERS	Surface-Enhanced Raman Spectroscopy
SFF	solid free-form fabrication

SHG	Second-harmonic-generation
SLS	selective laser sintering
T_e	electron temperature
Ti: Sapphire	titanium–sapphire
T_m	equilibrium melting point
UV	ultraviolet
Vis	visible
WDM	wavelength-division multiplexing
XRD	X-ray diffraction