26pC06

多極磁場中多相交流放電プラズマを応用した空間的放射一様性の高い光硬化用UV照射装置

UV photo-curing lamp-array with high spatial irradiation uniformity by applying a poly-phase ac discharge/plasma in a multi-pole magnetic field

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Introduction

Ultra-Violet (UV) photo-curing of hard coating is widely used in various industrial fields since it has no smell and takes only a few seconds. However, high pressure mercury lamps have been used, that consume large electric power and contain large amount of mercury. As issues concerned with energy and environment have become serious, the needs rise intensely for a new lamp that has no mercury and enable photo-curing under small electric power.

A lamp had been proposed by us, which contained no mercury but molecular gases and nitrogen and enabled photo-curing under ten times smaller electric energy than conventional ones. Demands for a lamp with high spatial uniformity and irradiating intensity are made from the point of view of practical & industrial use.

Experimental method and results

Figure 1 shows a photograph of visible light emitted from a set composed of six loop-shaped lamps arrayed in a plane, where gap spaces among lamps and four walls surrounding the set are wholly covered with aluminum reflectors. A six-phase ac power source (156kHz, ~300W) is supplied parallelly to six-divided electrodes. Figure 2 shows a typical spectrum irradiated from the lamp-set, where a nitrogen (90%) and oxygen (10%) mixed-gas is filled at the pressure of 0.5Torr. The component (UV I) ranging over 220-280nm is emitted from excited nitric oxide produced during the discharge/plasma, which enable photo-curing under small irradiation energy.

Figure 3 shows spatial irradiating UV distributions with respect to the horizontal direction, where data are measured at y=155mm, z=20mm. It was found that the horizontal distribution became considerably uniform over the full width when horizontal mirror-walls were located at the distance of half pitch of between adjacent lamps. Figure 5 shows spatial intensity distributions with respect to the longitudinal direction, where data are at x=84mm, z=20mm. We found that the longitudinal distribution also became fairly uniform over the full length when the longitudinal walls were located at the distance of 1~0.5 lamp's pitch. Furthermore, the results of spatial distribution with respect to the height direction indicated that the intensity were nearly constant over z=15~30mm.

The above feature of three dimensionally uniform irradiation distribution is industrially valuable in order to perform homogeneous UV photo-curing processes even if substrates have some curved surface.

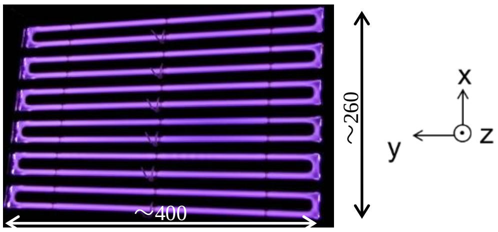

Fig.1 Visible light emission from the array of six looped-lamps, driven six-phase ac discharge/plasma

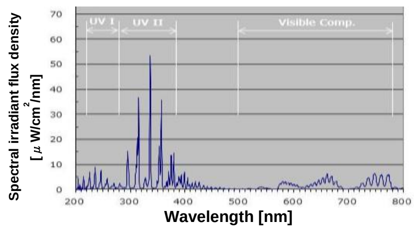

Fig. 2 Typical spectral irradiant flux density emitted from the UV lamp filled with a N_2 and O_2 mixed-gas

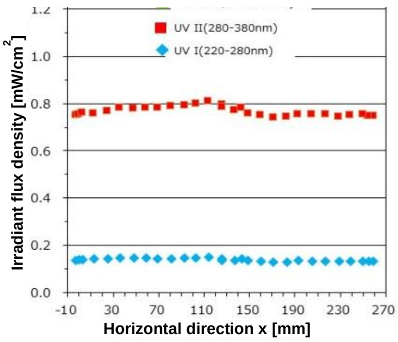

Fig.3 Spatial irradiant intensity distribution of the array with respect to the horizontal x-direction

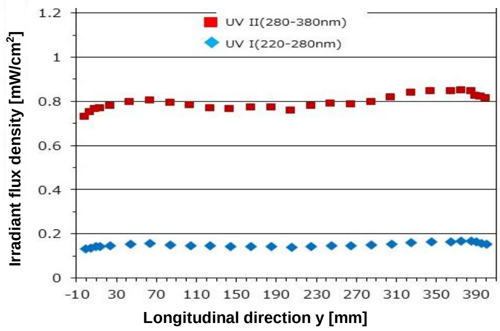

Fig.4 Spatial irradiant intensity distribution of the array with respect to the longitudinal y-direction