Current Applications

UV LEDs are successfully replacing mercury lamps in many niche applications and are also enabling the development of new applications. Figure 1 shows the application areas identified over different UV wavelength ranges as well as the radiant flux requirement for these applications. The material characteristics variation is also shown as a function of wavelength. While some applications such as gas sensing require a UV intensity of less than 1 mW/cm^2, certain curing applications may require intensities greater than 10,000 mW/cm^2. Applications such as sterilization may require up to 10 mW/cm^2, depending on the specific use. For example, water purification in a point-of-use flowing water system may require greater intensities than static water disinfection applications due to the high dosage requirements (Dosage = Intensity x Exposure time). For surface disinfection, the intensity may also be affected by the material of the object to be disinfected. For example, porous materials may require higher intensities to achieve the same level of disinfection. In addition, disinfection applications require the knowledge of UV dosages depending on the specific microbes to be inactivated.

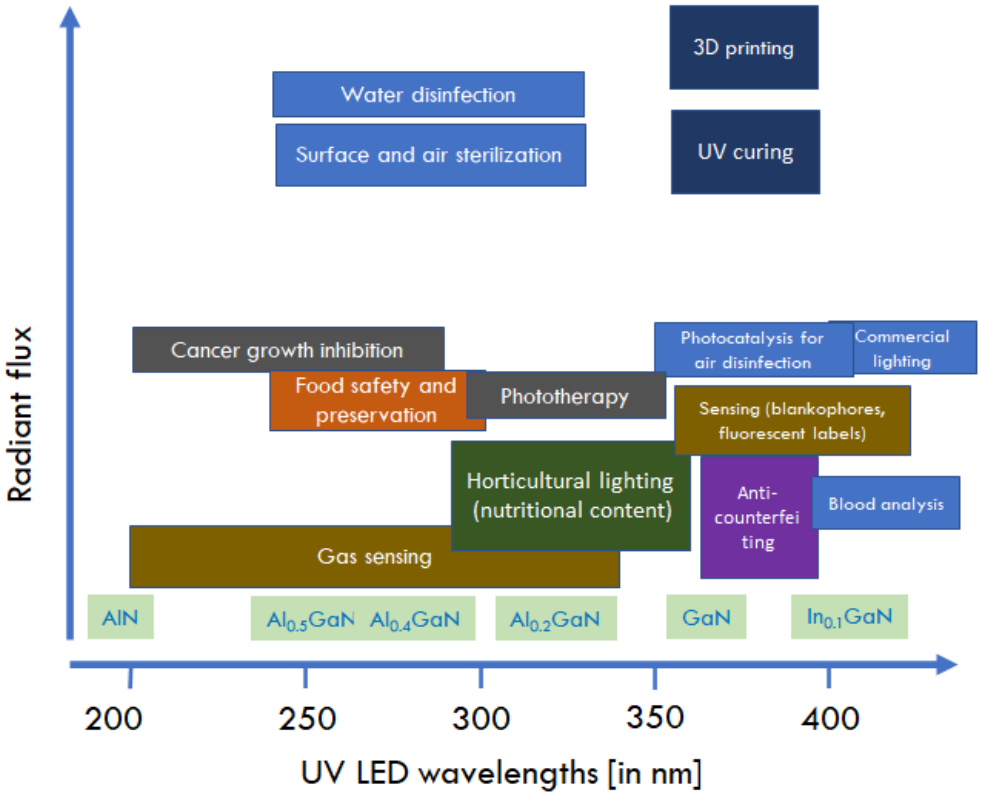

Figure 1: UV wavelengths are divided into UVA, UVB and UVC bands (adapted and redrawn) [6]

Applications in the UVA space are geared towards 3D printing and UV curing, requiring high UV intensities. UVA light with lower intensity is also used in photocatalysis [1] to excite electrons in TiO2 nanoparticles which further form reactive oxygen species and combine with harmful gases and volatile organic compounds and so finds applications in the air disinfection space. In addition, UVA is also used for counterfeit currency detection.

UVB LEDs are primarily being used in phototherapy [2], especially for the treatment of psoriasis and vitiligo and also for horticultural lighting applications [3]. UVB wavelengths are known to induce a mild degree of stress required to stimulate oxidative stress pathways and antioxidant mechanisms in plants and can play an important role in improving the nutritional content of certain produce pre- and post-harvest. UVB and UVC LEDs are also being used for a number of gas sensing applications as gases such as SO2, NOx, NH3 exhibit absorption bands in these spectral regions [4].

Sterilization and purification applications dominate the UVC space [5] due to the effectiveness in damaging and inactivating microbial DNAs; water disinfection being the most popular application. In addition, food safety and extension of produce shelf life using UVC are also gaining ground.

Another application of UVC LEDs is for non-line-of-sight communications. The benefit of using UVC LEDs for wireless communication is the negligible background noise as well as the elimination of line-of-sight transmission requirement for optical transmitters and receivers. However strong channel attenuation as well as exposure limits for humans make the design of communication networks challenging.

UVC LEDs are also being utilized in aquaculture applications to inhibit the breeding of bacteria and algae.

Choosing LEDs for Specific Applications

When it comes to selecting UV LEDs for a specific application, knowledge of the basics, described above, can aid in comparing UV LEDs. Some of these important questions may include:

- **What is the peak emission wavelength?:** The peak emission wavelength as well as the full-width half-maximum should be checked and chosen depending on application.
- **Radiant flux or optical output:** Depending on the dosage requirements, the radiant flux requirements would vary. There may also be a need for using an array instead of a single LED.
- **Beam angle of emission:** UV LEDs are typically packaged with optics to distribute the light in a region of interest. Optical simulations can aid in determine uniformity with specific optics.
- **Efficiency:** UV LED efficiency would have to be calculated from datasheets using the information on the optical output and the input voltage and current.

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