

via a mask or focused UV light beam offers great flexibility in the design of sensing hydrogel networks. In tissue engineering and biological sensors, biocompatibility of UV cured gel and its polymerization is an important issue because many monomer and photoinitiator residuals, as well as UV light show cytotoxic effects. Alternative photoinitiators for visible light curing include eosin Y and triethanolamine (Bahney et al. 2011) and, in addition, improved gelation rates by lithium phenyl-2,4,6-trimethylbenzoylphosphinate (LAP) (Fairbanks et al. 2009). Specialized gel systems, including hyaluronic acid vinyl ester (HAVE) (Qin et al. 2014) and gelatin methacrylate (Nichol et al. 2010) were introduced for three-dimensional cellular patterning with improved biocompatibility.

In recent years several excellent reviews on the synthesis and structure of gels (Hoffman 2001), biomedical devices (Deligkaris et al. 2010; Kirschner and Anseth 2013) and sensor applications (Buenger et al. 2012; Yetisen et al. 2015; Le Goff et al. 2015) have been published. In addition to these publications, this chapter provides an overview over the basic principles and especially emphasizes hydrogel applications in diagnostic procedures. The desire for miniaturized diagnostic systems has propelled the research field of lab-on-a-chip and microfluidic devices. Microfluidics is closely related to tissue engineering, in which hydrogels constitute a basic building block. The need to understand the fluidic microenvironment and the application of (soft) lithography techniques in the fabrication of hydrogel scaffolds and vascular networks demonstrates the affinity between these two fields. In addition, microfluidic devices are utilized to fabricate gel fibers and particles (Onoe et al. 2013; Takeuchi 2013) and vice-versa, hydrogels are utilized in lab-on-a-chip devices for sensing and diagnostics. One of the most prominent use for macroscopic gels in biomolecular research is their application in protein and nucleic acid separation by gel electrophoresis with subsequent staining (Magdeldin 2012). Other applications within lab-on-a-chip and diagnostic systems include cell-based biosensors, diffusion membranes, enzyme reactors, and physiochemical gel sensors, which are summarized throughout the following chapter.

Structural Engineering of Gels in Sensing Applications

For the integration of three dimensional hydrogel networks in sensors, several design parameters have to be considered. As the quantity of interest has to interact with the bulk gel, the response time of the sensor is determined by the dimensions of the gel. In addition, the mechanical structure and pore size influence the sensor performance. Important microfabrication and structure tuning techniques for gels in the micrometer range are highlighted in the following.

Microstructuring of gels

In diagnostic devices, the analyte of interest mainly is a chemical species of any kind. The transport of molecules is governed by diffusion, with the diffusion time t :

$$t \approx \frac{l^2}{2D}$$