Magnetic field-assisted DNA hybridisation and simultaneous detection using micron-sized spin-valve sensors and magnetic nanoparticles

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Abstract: Specifically designed on-chip microfabricated current-carrying metallic lines were used to generate local magnetic field gradients to facilitate the rapid focusing and hybridisation of magnetically labelled target DNA with complementary sensor-surface-bound probe DNA. Magnetoresistive biochips featuring high sensitivity spin valve sensors (2 μm × 6 μm) integrated within aluminium current lines, tapered in diameter from 150 to 5 μm at each sensor location, were surface functionalized with probe DNA and interrogated with 250 nm magnetic nanoparticles functionalized with complementary or non-complementary target DNA. Currents of 20 mA were used to rapidly concentrate and manipulate the magnetic nanoparticles at sensor sites in minutes, overcoming the diffusion limited transport of target DNA that leads to long hybridisation times. On-chip target DNA concentrations between 10 and 200 pM resulted in magnetoresistive hybridisation signals of 1-2 mV at 8 mA sense current, equivalent to 50-100 sensor-bound nanoparticles. The noise level (20 μV) was at the level of a signal calculated for a single nanoparticle (18.8 μV). Each nanoparticle was functionalized with <500 DNA molecules with an estimated 70 DNA-DNA interactions per nanoparticle at the sensor surface. The detection range was 140-14,000 DNA molecules per sensor equivalent to 2-200 fmole/cm2. No binding signals were observed for magnetically labelled non-complementary target DNA.

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