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MATTHEW DIXON*

ABSTRACT

Because patents are critical in nanotechnology, investors, lawyers, and managers must carefully monitor the issuance of new patents. While most companies are focused on patent issuances in the U.S., they should also keep a careful watch on European patent grants. Not only is Europe a key market, but, in many cases, the European post-grant opposition period provides the first opportunity for a company to challenge a competitor's patent that has been filed throughout the world. In this article, European patent lawyer Matt Dixon reviews several key nanotechnology patents granted by the European Patent Office (EPO). He also reviews several cases decided by the EPO's Board of Appeals.

The recent growth of industrial research and development in the field of nanotechnology is a global phenomenon. This article reviews some of the patents already granted this year by the European Patent Office (EPO) to European companies developing technology on a nanometer scale. Also reviewed are recent cases from the EPO's Boards of Appeal in this technical field.

I. EUROPEAN NANOTECHNOLOGY PATENTS

In the field of electronic components, Hitachi Europe Limited has been granted a patent (EP 802633) for a binary decision diagram logic device. According to the patent, binary decision diagram devices differ from traditional combinational logic in that they are based on a tree structure, rather than AND/OR gates. In such a device, a messenger signal from a "root" travels to a "node" where it will pass to one of two "branches" depending on whether the node has been set high or low. In a device with several nodes and branches, the messenger signal eventually arrives at one of several "leaves" which represent the possible outputs of the device. The leaf at which the messenger signal is detected determines the output of the device.

In Hitachi's patent, the nodes receive electrical charge to a level limited by Coulomb blockade; the level at which the energy due to the accumulated charge is greater than the thermal energy of the charge carriers. Respective potential barriers, in the form of tunnel junctions, are provided between the node and each of the possible branches and a side gate voltage is applied to each potential barrier to determine which branch is to be selected. When a clocking voltage is applied to the potential barriers, electrons tunnel preferentially through the selected potential barrier along the required branch. According to the pat-

* Mr. Dixon (mattd@frankbdehn.com) is a partner at Frank B. Dehn & Co., one of Europe's largest firms of patent attorneys. The firm files in excess of 1,000 European patent applications a year in all areas of technology and has been involved in over 500 opposition cases before the European Patent Office.

ent, the advantage of the device over traditional arrangements of transistors is that it does not require as much space or power when used in large-scale integrated circuits.

The German specialist manufacturer of magnetic alloys, Vacuumschmelze GmbH, which since 1999 has been a division of the British company, The Morgan Crucible Company plc, has been granted two patents (EP 801443 and EP 809263) directed to inductive components utilizing nanotechnology. The first is an attenuation device for high-frequency noise which includes an inductor formed of a toroidal core of amorphous or nanocrystalline material. The toroidal core forms one electrode of a capacitor connected between the ground potential and the conductor carrying the noisy signal. The toroidal core is applied to a pin within a connector housing so that additional components are not required, resulting in a compact design. The second patent is directed to a flat inductive component that includes a magnetic core of a nanocrystalline iron-base alloy or an amorphous cobalt-base alloy. According to the patent, the use of these alloys in the magnetic core allows the number of windings to be reduced relative to ferrite cores so that the length of the leakage paths between turns at different potentials can be increased.

The privatized German telecommunications company, Deutsche Telekom AG, has been developing filter systems for wavelength division multiplexed optical telecommunications networks. A recent patent (EP 907089) claims a crystal-optical interference filter with periodic spectral pass band, which provides a cost-effective device for use in WDM systems. The filter includes a birefringent element in the form of a single crystal of a mercury-1-halogenide, which is able to achieve a difference in refractive index between the fast and slow axes approximately five times greater than calcareous spar, a previously used material.

It is not only commercial companies that have been working on applications of nanotechnology to optical systems. The French government has been granted a patent (EP 1014162) for a method of limiting the intensity of a flux of radiation by placing a liquid or solid medium containing nanotubes in the path of the radiation. At ambient light levels, the medium containing the nanotubes appears transparent. However, if the medium is subjected to a powerful flux of radiation, the radiation is attenuated to an acceptable level by the medium. A photoactive device employing the method can be used to protect an optical system, such as a missile guidance system, from potentially damaging radiation levels.

One unusual patent in this field is that granted to Andre Hogrefe, a German graduate mineralogist. The patent (EP 1083145) is unusual among European patents in that the inventor appears to have obtained this patent without professional representation. The patent claims "A fibrous, nanoporous, high-temperature-resistant, polycrystalline magnesium hydroxide hydride having the chemical composition $Mg(OH)_2 \cdot H_2$ or $Mg(OD)_2 \cdot D_2$," which can be used in a gas diffusion electrode as a solid-state electrolyte. Other possible applications of the claimed material are as an absorber or catalyst in gas sensing, or to produce containers for the glass processing industry that require a smaller amount of energy to melt the glass.

The Particle Technology Laboratory of the Swiss Federal Institute of Technology in Zurich appears to be particularly active in the field of nanoparticles. Degussa AG, a German specialty chemicals company, has been granted a European patent (EP 1122212) in respect of "composite carbon black-fumed silica nanostructured particles." The inventors are Prof. Dr. Sotiris E. Pratsinis, the Director of the Laboratory, and his research associate, Dr. Hendrik Kammler. The patent claims the particles *per se*, as well their use as a filler in rubber, as a thixotropic agent, and as an abrasive.

Vesifact AG, a spin-off from the Swiss Federal Institute of Technology, has been granted a patent (EP 852941) for a nano-dispersion cosmetic preparation, which can be used for skin care. Indeed, nanoemulsions appear to be a popular application of nanotechnology in the cosmetics and healthcare field. For example, L'Oreal, the French cosmetics company, has been granted a patent (EP 1172077) for an oil-in-water nanoemulsion, and Yamanouchi Europe BV, the European marketing organization of Yamanouchi Pharmaceutical Co., Ltd, has patented (EP 786251) a nanoemulsion for a cosmetic preparation. In

the healthcare field, the Spanish company Alcon Cusi SA, a subsidiary of Alcon Laboratories, Inc., has patented (EP 696452) an oil-in-water nanoemulsion for use as a drug delivery vehicle in ophthalmology. According to the patent, the nanoemulsion increases the bioavailability in the eye of the drug in the vehicle.

Two German companies have applied the surface properties of nanolayers to the field of personal hygiene. Franz Kaldewei GmbH & Co. KG, a European market leader in the manufacture of bathtubs and shower trays, has patented (EP 881070) a method of making a sanitary tub in which an acrylic sheet is coated with a lacquer of solvent and nanoparticles, and the acrylic sheet is thermoformed into the tub. According to the patent, the tub has improved abrasion resistance.

Similarly, EP 1063167 to Airbus Deutschland GmbH claims a vacuum toilet system in which the components that come into contact with waste products are provided with a nanolayer. The nanolayer prevents retention of waste products on the surfaces of the toilet system to such an extent that the toilet requires no flushing water to achieve the necessary standards of cleanliness and hygiene. Without a liquid flush system, the weight of the toilet system is greatly reduced, which is a significant advantage when the system is fitted in passenger aircraft.

Nanofiltration is also featured in the European patents granted so far this year. The Environmental Analysis Center in Gröditz, Germany, has patented (EP 968756) a method of treating spent acids containing metal salts that have been used in processes such as hot-dip galvanization. The acid is first purified by cross-current micro- or ultra-filtration to remove undissolved solid constituents, and is then nanofiltered to separate the free acid from the dissolved metal salts. According to the patent, the process provides the first economically satisfactory low-waste solution to the problem of regenerating spent acids.

Another purification process is claimed in EP 949199, granted jointly to Horcom Limited, Trinity College Dublin, and Enterprise Ireland, the Irish government's enterprise development agency. The process for purifying nanotube soot involves adding nanotube soot to a solvent containing an extracting material with a coiling structure and mixing the solution to form a nanotube composite suspension that is removed after separated solid material has been allowed to settle. According to the patent, the process improves upon prior purification techniques, such as the use of strong chemical oxidants, surfactants, or burning, in that it is less destructive of the nanotubes.

II. OPPOSITION PROCEEDINGS

1. EP 168091

Before the EPO's Boards of Appeal, a fourteen-year legal battle involving some of Europe's largest chemical companies has come to an end with the re-issue of EP 168091, just over two years before the patent is set to expire. The patent, originally granted to Unilever BV in 1988, claimed a nickel/alumina catalyst defined in terms of its nickel/aluminum atomic ratio, average pore size, active nickel surface and the average diameter of the nickel crystallites. Shortly after the patent was granted, oppositions were filed by two German chemical companies, Hoechst AG and Süd-Chemie AG, and a Dutch chemical company, Engelhard De Meern BV, a subsidiary of the Engelhard Corporation.

In 1991, the patent was revoked by the Opposition Division, who deemed the feature of the average pore size too vague to distinguish the claimed catalyst over known catalysts cited by the opponents. This decision was overturned on appeal in 1995 and the case was remitted to the Opposition Division, who then upheld the patent in 1997 on the basis of an amended claim characterized by the method of preparing the catalyst, a so-called product-by-process claim. In response, Engelhard De Meern BV filed an appeal

against this Decision, which was eventually rejected by the Board. The patent re-issued in amended form this year and is now owned by Unichema Chemie BV, a subsidiary of Imperial Chemical Industries plc.

This case highlights the length of time that some opposition cases have taken to reach a final decision. This problem has been recognized by the EPO, which is attempting to speed up the progress of opposition and appeal cases by taking a strict approach to the introduction of further grounds and evidence once an opposition or appeal is underway.

2. EP 536995

In the ongoing opposition by Exxon Chemical Patents Inc. against EP 536995 of Wisconsin Alumni Research Foundation, the Board of Appeal has summoned one of the inventors, Professor Marc A. Anderson, of the University of Wisconsin, to give evidence in person before the Board. Professor Anderson is the first named inventor in the patent, which claims a microporous ceramic membrane of alumina and silica. The patent was granted in December 1996, but was revoked by the Opposition Division in November 1998 after Exxon filed an opposition.

The patentee filed an appeal and the Board is now requiring Professor Anderson to explain what he disclosed at a conference in Seville, Spain the day before the first patent application for his invention was filed in the USA. This is an unusual case, as it is relatively rare for oral evidence to be presented in European opposition and appeal proceedings, which are a predominantly written procedure. Early publications by academics, who are always keen to present the results of their research to their peers, can be a problem in relation to European patent law, because the novelty of the invention is judged strictly at the filing date of the first application. Hence, it is always important to ensure the patent application is on file before the invention is publicly disclosed.

Even from the above snapshot of cases, it can be seen that the results of nanotechnological research in Europe are being applied across a vast range of industrial fields, from pharmaceuticals and cosmetics to electronic components. As has been seen in other new fields, such as biotechnology and e-commerce, the European Patent Office is granting broad patents where there is no established body of prior art to cite against the new cases. Compared to biotechnology and e-commerce, inventions in the field of nanotechnology are generally less subject to the exclusions to patentability set forth in the European Patent Convention, such that there may be even fewer restrictions on the scope of available protection. Time will tell whether broad patents in this field will withstand oppositions that may be filed by competitors.

III. CONCLUSION

Certainly, companies looking to commercialize their nanotechnology in Europe would be well advised to keep a watch for new patents that may restrict their activities and to consider opposing such patents within the nine-month post-grant opposition period. This not only applies to European patents granted to European companies, such as are discussed in this article, but also to those granted to applicants from outside Europe—such as US and Japanese companies. In many cases, the European opposition is the first convenient opportunity for an active attack on the validity of a competitor's patent that may have been filed throughout the world. It remains to be seen who will emerge victorious from the patent battles that will undoubtedly arise in this rapidly developing field.