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nano

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GEAR UP FOR GOLD

Nano is changing the sports arena

Bendy chips
Flexible, stretchable circuits

To the Extremes
Nano to withstand the harshest environments

Christoph Gerber
Microscopy pioneer's visions for the future

Small country, Big ideas
Switzerland's nanotech environment

Plasma
New treatments for functionalised textiles

Nanosensors
Big benefit or big brother

What's new in nano
Keep up with the latest news

PLUS: FINE TUNING OPTICAL TECHNIQUES FOR SELECTIVE FLUORESCENCE

FEATURE

Nanosensors
Big Benefit or Big Brother

BY SHIRLEY COYLE AND DERMOT DIAMOND

TEXTILES AS A UNIVERSAL INTERFACE ARE CONSTANTLY INTERACTING WITH OUR BODIES AND THEIR ENVIRONMENT, THEREBY PRESENTING AN IDEAL PLATFORM FOR PLACING OR INTEGRATING SENSING DEVICES. WHILE THE EARLIEST SENSING GARMENTS HAVE APPEARED AS CUMBERSOME DEVICES, WITH TRIED AND TRUSTED MACRO-ELECTRONICS ATTACHED ON TOP, NEW TECHNOLOGY IS ENABLING A MORE SEAMLESS INTEGRATION.

Nanotechnology is solving the problems of connecting hard, brittle electronics with soft, pliable textiles. "Smart" garments with integrated nanosensors are now becoming wearable rather than portable.

A 'smart' garment must be just like any other garment in our wardrobe, i.e. comfortable, durable, washable and be able to withstand the general hardship that we put our clothes through every day. This is critical for wearable technology to move outside of the laboratories and into realistic settings.

Through the use of functionalised fibres and yarns the fabric itself becomes the sensor thus creating garments with inherent sensing capabilities. Conductive metallic yarns are knitted or woven to create electrodes for ECG signals, while piezo-resistive conducting polymer fabrics may be used to measure breathing patterns, gait and joint movements.

Textile-based nanosensors form part of a personalised healthcare system providing valuable information regarding the wearer's physiology. This empowers the wearer with an increased awareness of their own health status which may serve to reinforce a healthy lifestyle, monitor fitness levels, provide early detection of illness and prevent disease.

By gathering data in the home and community setting, nanosensors can help overcome the problems associated with clinical visits, which only provide a snapshot of personal health status. Vital signs such as heart rate, respiration and temperature can be measured on a continuous basis. Wearable sensors allow remote monitoring of a patient, in familiar surroundings, thus facilitating a more normal lifestyle, uninterrupted by time-consuming hospital visits that often contribute to patient anxiety and stress.

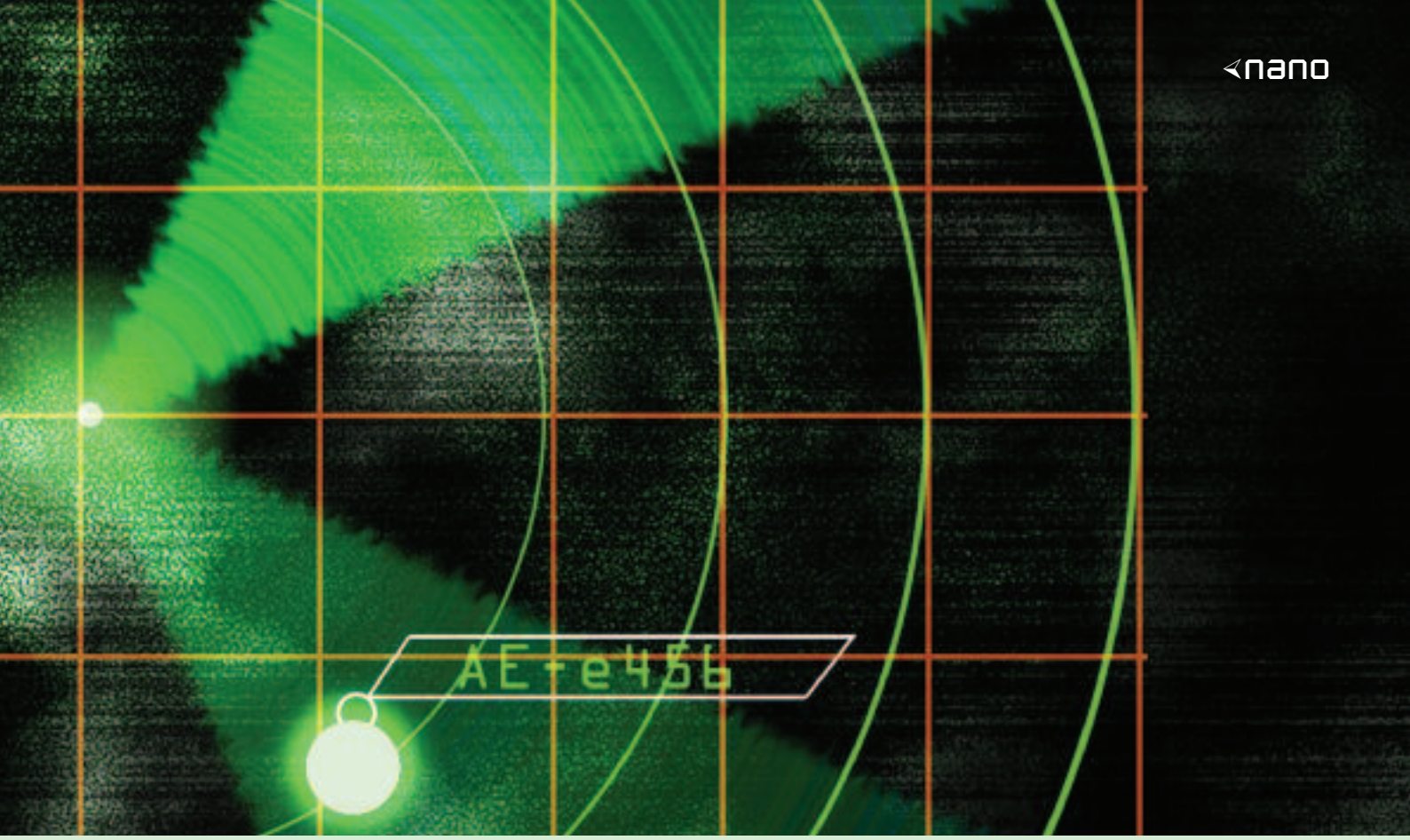
By 2050 approximately 20% of the world population will be at least 60 years old, and the healthcare system must adapt to cope with this demographic change.

Nanosensors embedded into clothing or home textiles may be used to monitor health and activity while nanosensors furnishing a "smart" home provide a network of intelligent devices that learn the user's routine and respond accordingly.

A central monitoring unit can aggregate information from the physiological and environmental sensors and contact a relative or ambulance in the event of an emergency. This type of monitoring technique has many applications related to home care of patients with cognitive impairments such as Alzheimer's, geriatric dementia or psychological problems.

Remote health monitoring is a key strategy that can increase autonomy and assist in the activities of daily living enabling people, who currently may require high-cost constant caring, to continue to live largely independent lives.

While nanosensors can have huge potential in the healthcare sector, there are many other applications of this technology. Just recently at the Beijing Olympics we saw how highly engineered textiles have assisted in breaking records in swimming through the use of swimsuits that minimise



drag, while also reducing muscle fatigue. The sports industry is continually using technology to increase capabilities and push athletes to higher limits.

Nanocoatings are producing better moisture wicking fabrics to keep the wearer cool and comfortable. Nanosensors embedded into sportswear allow athletes to track their performance and develop a personalised training program.

The importance of using new functionalised clothes is that athletes can be monitored during normal training sessions, i.e. they can train as usual out on the track or on the football pitch, as opposed to being hooked up to machines in a lab.

Body position and limb movements can be recorded in addition to physiological data such as heart rate and breathing patterns. Novel research into on-body chemical sensors may assist in developing personalised nutritional and hydration strategies. These applications are not restricted to the elite athlete, but increasingly apply to all levels of ability in order to maximise the benefits of a work-out.

In the gym, aerobic training machines display the number of calories burned, distance travelled and have an inbuilt heart rate monitor to keep the user within training zone specifications. Nanosensors can take this a step further in providing individual monitoring and assist in personal achievement of training goals, outside of the specialised gym environment.

In extreme environmental conditions and hazardous situations there is a need for real-time information technology to increase the protection and survivability of the people working in those conditions. Improvements in performance and additional capabilities would be of immense assistance within professions such as the defence forces and emergency response services.

Nanosensors may be used to monitor vital signs and ease injuries while also monitoring environment hazards such as toxic gases. Wireless communication to a central unit allows medics to conduct remote triage of casualties to help them respond more rapidly and safely. Monitoring in such scenarios is of huge benefit by increasing the efficiency of the team as a whole and also the safety of each individual. This technology may open up a wide range of other markets where people are faced with hazardous activities, from extreme sports through to transportation maintenance and building workers.

There are other applications extending past healthcare and human performance where nanosensors have a part to play. Fashion and art have always had a strong overlap, and what better way to portray interactive art than through the clothes we wear?

XSlabs have used wearable technologies and sensors to focus on aesthetics, personal expression, and the idea of play. Designers such as Hussein Chalayan are bringing haute tech couture to the catwalks of Paris, with luminated fabrics and mechanical dresses.

Clothes may be programmed to respond to our mood, physiology or environment. This could be a heated glove which switches on when we are cold, a hat that tells us we are too tired to drive, or a shirt that lights up when we are excited. Aesthetics are an important factor of what we wear and responsive garments may be used as a visual expression of inner emotions, if that is what the wearer chooses. Therefore nanosensors have an important contribution to make, pushing the boundaries of creativity, and it is up to us individually to choose how we use them in innovative ways.

So if we have a shirt to monitor our daily activities along with our fitness level and general health, is it an intrusion of our existence?

It depends how the information is being used. If personal data is being circulated ➔

within a communications network, it is vital to ensure that encryption and security methods are in place. Patient confidentiality must be preserved and the users' informed consent must be given.

As wearable sensors are integrated into the field of e-health it is important to uphold the e-Health Code of Ethics. This policy "is to ensure that people worldwide can confidently and with full understanding of known risks realise the potential of the Internet in managing their own health and the health of those in their care". This must therefore apply to all nanosensor applications that relate to an individual's personal health.

Another concern related to remote health monitoring is that virtual visits threaten to turn physicians and nurses into distant medical technicians and technology may cut off the trust and close contact between doctor and patient. In recent years patients' perception of doctors has changed, and they are no longer regarded as the paternalistic figures they once were, but rather as a technician to health services. This must be weighed up against the very considerable benefits of remote monitoring with the added well-being of a patient being treated in their own home, rather than in a hospital or some other impersonal institution.

Provided moral and ethical standards are in place and that users are kept aware of the operation of monitoring systems there is no doubt that these tiny devices offer huge potential in many areas of our lives, giving us access to the right information at the right time.

One thing is certain, the current model of healthcare delivery is unsustainable, and it is clear that delivery of health services must become increasingly distributed, with more status monitoring happening locally, on an individualised basis. Associated with this is the realisation that we need to take more responsibility for our own health, and systems need to assist people to remain independent to a much greater degree than happens at present. The implementation of this vision depends critically on technologies like wearable sensing. ✪

Shirley Coyle and Dermot Diamond are researchers at CLARITY: The centre for web technologies bringing information to life (see side panel)

CLARITY, a Science Foundation Ireland funded Centre for Science, Engineering and Technology, has a mission to "Bring Information to Life". This refers to the harvesting and harnessing of large volumes of sensed information, from both the physical world in which we live, and the digital world of modern communications & computing. While this may suggest a "Big Brother" type world the motivation of the research is to benefit the citizen by improving their quality of life through a new generation of smarter, more proactive, information services. One area of research is focussing on functionalised fabrics used to create "smart" clothing that can monitor and respond to the wearer.

Further reading

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