The NCKU Smart Campus Project: An Experiment Towards Smart Cities

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“Smart city” has become the new trend of the world’s city development in the 21st century. The traditional cities are composed of concrete, steels, bricks, and glass. Unlike traditional cities, a smart city develops its nervous system through the Internet, supporting the daily life of billions of people. The city's nervous system manages the operation of space and infrastructure, and then with the public portable devices, Internet of things, and artificial intelligence, the city more and more smart. The city infrastructure will continue to be upgraded and evolved. In the future, a large and number of smart technologies that control our physical world and provide intelligent living services is no longer a dream.

In order to develop the smart city, NCKU initiated a smart campus project supported by Architecture and Building Research Institute, Ministry of the Interior since 2016. The smart campus project takes the NCKU campus as a micro-city experimental field. The NCKU smart campus is developed in six dimensions: mobility, environment, sustainability, health, education, and data, which is in short called MESHED. The goal is to install sensor networks, smart infrastructure, cloud services in the NCKU smart campus. Through the analysis of big data, innovation and integration services, as well as the development of new business models, the NCKU smart campus draws a blueprint for the next century’s city of the future.

The first-year pilot experiment has transformed the C-Hub courtyard from a rural space into a smart, green, and interactive base in support of creative activities in the College of Planning and Design. The construction and installation include the sensor networks that can sense atrium outdoor air quality, and smart meters that can monitor the sue of electricity. The second-year experimental projects include air quality management system through sensor networks spreading out of the entire campus, eco-museum with i-beacons installation in the main campus, and a self-served public biking system. The experimental projects are followed by analysis of big data, innovation of public services, as well as the development of new business models to optimize the cost and methods. In the third year, the NCKU smart campus project will be integrated into the Tainan city to build a collaborative initiative. The NCKU smart campus project has proven a paradigm shift with a concept of the triple helix of university-industry-government relationship, which fills the gap in the region’s innovation environment.

Figure 1: the C-Hub courtyard rebuilt with air quality sensors and smart electricity meters
Figure 2: the NCKU Smart Campus is installed with sensor networks to monitor air quality in campus

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Thermoelectric phenomena on thermoelectric generator surface under temperature oscillation.

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Thermoelectric generators (TEGs) are a device to convert heat into power. Because low-temperature waste heat can be harvested and turned into electricity by TEGs, they are a promising facility in the green energy development. However, the efficiency of TEGs is low. How to improve the efficiency of TEGs via materials, system design or operation has become an important task for TEG development. TEGs are operated by means of the thermoelectric effect[1], which pertains to a solid-state energy conversion route between heat and electricity where the interaction among the electric field, current and heat is involved. Seebeck effect, Peltier effect and Thomson effect are three important thermoelectric effects[2].

To improve the performance of TEGs, we devote ourselves in the design and optimization of thermoelectric system over the last decade. One of the topics studied is the effect of oscillating temperature on the module’s surfaces upon the performance of a TEG. As shown in Fig. 1, the temperature at the hot-side and cold-side surfaces are approximated by sinusoidal functions where the amplitudes at the two surfaces and the phase angle of the sinusoidal waves are controlled. The results suggest that the average output power and efficiency increase with increasing the amplitudes, but the absorbed heat is affected slightly. The figure-of-merit (ZT) of a material plays a key role on the performance of a TEG[3]. The study also indicates that the mean efficiency can be lifted by a factor of 1.71 once the ZT value goes up from 0.736 to 1.8 at the phase angle of 180 °, and the maximum efficiency is 8.45%. It is concluded that the performance of TEG can be intensified via appropriate controls of the oscillating temperatures on the surfaces and their phase angle. These findings are conducive to the utilization of low-temperature waste heat and development of green power.
Figure 1. A schematic of temperature oscillation on the surfaces of a TEG and its performance.

Reference

Previous studies indicated that crying behavior of full-term and preterm infants show significant different patterns due to immature neurological development of preterm infants. Long-time average spectrum (LTAS) was used to analyze the cry phonation of 26 infants under four months old. Sixteen of them are full-term and the other 10 infants are preterm. The results of first spectral peak (FSP), mean spectral energy (MSE), spectral tilt (ST), high frequency energy (HFE) were used to compare the cry phonation between full-term and preterm infants. Major findings are: (1) Term infants had longer overall cry duration, which corresponded to better respiratory capability to support phonation; (2) There was no significant difference across groups in the percentage of cry utterance; (3) FSP in term infants involved more distinct phases across three partitions, declining toward the end of cry episode; (4) Preterm infants showed higher MSE, which corresponded to tighter laryngeal muscle and intense cry production; (5) There was a quicker reduction of energy with larger ST in preterm infants over time, which revealed hypoadduction of the vocal folds; (6) There was a significant decline of HFE over time in both term and preterm infants. The differences in the measures of crying behavior between full-term and preterm infants can help to estimate health condition of infants who are under 4 months old in order to provide adequate care.
Advanced transistor structures such as the 3-D tri-gate MOSFET have been adopted at the 22-nm CMOS technology node because they can better suppress short channel effects than the conventional planar bulk MOSFET structure. Gate-all-around MOSFETs relevant for the 11.9 nm CMOS technology node are optimized with device dimensions following the scale length rule. Variability in transistor performance due to systematic and random variations is estimated with the aid of TCAD 3-D device simulations, for these well-tempered GAA structures. Our results indicate that a rectangular (thin and wide) channel design achieves the optimal balance between read yield and write yield and hence provides for the lowest minimum cell operating voltage, estimated to be ~0.45 V, as well as smaller cell area.
Autophagy-preferential degradation of MIR224 participates in hepatocellular carcinoma tumorigenesis

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Autophagy and microRNA (miRNA) are important regulators during cancer cell tumorigenesis. Impaired autophagy and high expression of the oncogenic microRNA MIR224 are prevalent in hepatocellular carcinoma (HCC); however, the relationship between the 2 phenomena remains elusive. In this study, we are the first to reveal that autophagy selectively regulates MIR224 expression through an autophagosome-mediated degradation system. Based on this finding, we further demonstrated that in hepatitis B virus (HBV)-related HCC, aberrant autophagy (low autophagic activity) results in accumulation of MIR224 and decreased expression of the target gene Smad4, which leads to increased cell migration and tumor formation. Preferential recruitment of MIR224 into the autophagosome was clearly demonstrated by a) miRNA in situ hybridization under confocal microscopy, and b) immunogold labeling of MIR224 under electron microscopy compared with a ubiquitously expressed microRNA MIRlet7e/let-7. Furthermore, we found that off-label use of amiodarone, an antiarrhythmic agent, effectively suppressed HCC tumorigenesis through autophagy-mediated MIR224 degradation both in vitro and in vivo. In summary, we identified amiodarone as a new autophagy inducer, which may provide an alternative approach in HCC therapy through a novel tumor suppression mechanism (fig. 1).

Figure 1. The mechanism of autophagy regulation miR-224 expression and HBV-related tumorigenesis. (1) The red
arrows show that low autophagic activity accumulates miR-224 and then promotes cell migration and tumor formation through silencing target gene. (2) The green arrows show that miR-224 is selectively engulfed and degraded in the autophagosome.

References:

Revolutionary Views on Periodic Bands in Polymer Spherulites

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Historically, in the past 60 years, continuous spiral twisting of polymer lamellae caused by chain folding induced unbalance surface stresses had been believed as a plausible mechanism for common optical ring-banding behavior in polymer spherulites. With progress of powerful advanced instrumentation and newer discoveries of diversified patterns (e.g., birefringent vs. non-birefringent; circular vs. hedral/hexagonal; concentric vs. helicoidal, etc.) of ring bands in increasing numbers of polymers under different environment, more and more work reported behavior that contradicted interpretations based on such idealized models. This feature article reviews and surveys evidence accumulated in past years by numerous investigators to point out that polymer spherulites are made of complex hierarchical polycrystals with multiple branches during primary and secondary growth that are supported by clear experimental observations; thus, assumption of a single-crystal lamellae plate undergoing continuous spiral from center to peripheral of spherulite may need critical assessment for validity.

There are four critical points that we would like to bring forward for discussion. Firstly, numerous investigators since 100 years ago have amply reported (even far before discoveries of ring bands in polymer spherulites) that many small-molecule compounds, apparently without chain-folding induced surface stresses, could display exactly same orderly ring-band patterns in their crystals as those in polymer spherulites. Secondly, crystal lamellae, being in either polymers or small-molecule compounds, do twist or scroll in responding to various external stresses; however, critical experimental evidence for matching between the twist pitches and optical inter-ring spacing, for some unknown reasons, has been lacking in past 60 years. Thirdly, it takes synchronized twists of tens of thousands lamellae that all have to be identically shaped single crystals that might be a dauntingly impossible task for polymer crystals in order to build orderly ring bands in a spherulites as viewed in optical graphs. Finally, conventional analyses were usually based on characterization on the top-surfaces of thin films (several micrometers, with top surfaces etched or unetched) of crystallized polymers; or alternatively, polymers were cast to ultra-thin films (nanometers) for viewing on the morphology of single crystals. Although lamellae scrolling and twisting may be proven in single crystals of some polymers owing to chain-fold induced stresses or other external forces, extrapolation of possible correlations of scroll/twist in single-crystalline lamellae to the ring-banded patterns in polycrystalline spherulites is still not yet established. Thus, in this article, top morphology and crystal patterns on the outer surface in correlation with the interior crystal lamellae of ring banded spherulites in several common polymers was established. Novel approaches on dissecting the interiors of ring-banded spherulites in crystallized polymer bulks, as well as thin films, are discussed in details. Figure 1 summarizes the formation mechanisms of different periodic bands: radial-stripes bands (1) and various types of circular ring-bands (2-4) in polymer spherulites interpreted from surface and interior analyses.
The subjects in “periodic bands in polymer spherulites” would not be complete without subject of radial-striped spherulites in comparisons with circular ring bands. Radially striped spherulites of opposite birefringence will be demonstrated first before moving into circularly ring-banded spherulites. There are some connections of mechanisms of formation and growth between the radial-striped spherulites and circularly ring-banded spherulites. PEO/PVPh (80/20) spherulites appear to radiate out from the nuclei center, branch out, and bend to curvature, as they go from center to periphery displaying two contrast blue and orange striped bands. AFM analysis, in direct correlation to the POM results, reveals that all the orange-color-stripe lamellae are oriented to –45°, while all blue-color-stripe lamellae are oriented to +45°. These perpendicular oriented crystals are forming contrast blue and orange stripes in POM graphs. Similar hedritic spherulites with opposite blue/orange stripes are also seen in poly(L-lactic acid) (PLLA) blended by mixing with 20 wt% atactic poly(methyl methacrylate) (aPMMA) \[^1\].

A more perplexing phenomenon is that a polymer, crystallized at a same Tc, may display two or more types of ring-banded spherulites that differ entirely in optical birefringence patterns and lamellae structures. The complexity in such phenomenon makes it even more difficult to interpret the banding behavior using a monotonous and continuous spiral lamella models. This is exemplified in a recent study on ring-banded behavior of poly(nonamethylene terephthalate) \[^2\]. Two types of ring-banded spherulites are present in poly(nonamethylene terephthalate) (PNT), Type-1 is regular extinction ring and Type-2 shows banded ridges with slanted crystals. Crystals in the ridge band of Type-2 spherulites are oriented perpendicularly to the crystals in the valley band. The perpendicular orientations in the valley vs. ridge reasonably account for the alternating blue/orange color circular ring-bands in POM graphs.

Circular ring-bands spherulites with a very long pitch (50~100 µm) are easily found in crystallization of PLLA \[^3-5\].
For probing the interior lamellae morphology of large-pitch PLLA ring-banded spherulites, water-soluble polymer PEO was used for blending with PLLA (50:50 by weight). The reason that PEO was used for probing the interior PLLA lamellae was two folds: (1) PEO is miscible with PLLA and acts as diluent to induce orderly ring bands in PLLA, and (2) PEO is easily water soluble and can be readily etched out from the PLLA lamellae without risk of deforming the crystal shape. SEM graphs of the fractured and water-etched interiors of PEO/PLLA (50/50) blend expose interesting correlations between the lamellar plates and crack orientations. Interior lamellae assembly is also exposed for clear correlation with the ring band patterns on the top surface. Lenticular-shape radial cracks are visible only on the ridge band (bulge band) of spherulites on the top surface and are oriented in the radial direction. The ridge band is composed of parallel lamellae plates that are perpendicular to top surface of polymer films; thus, cracks between the parallel edge-on crystals are visible (in SEM graphs) on the ridge band. The schemes reflect the actual fractured morphology in SEM graphs, which clearly show that voids are not only on the top surface but also on the hidden interior exposed by the fracture surface. These advanced analyses on interior of lamellae in ring-banded spherulites with crack patterns of crystallized PLLA/PEO mixtures have yielded critical evidence on understanding not only the true mechanism of ring band formation, but also how and why cracks (radial and circumferential types) accompany and follow the ring band patterns.

Poly(ethylene adipate) (PEA) is an intensively studied system for understanding the mechanisms responsible for ring-banded behavior. However, although numerous theorized claims by many investigators attempted to prove that lamellae twist into helices and synchronizingly rotate to create ring bands, however, so far in the past 60 years, there has been no evidence presented by investigators to show that the lamellae pulled or retrieved from ring-banded PEA spherulites do show twisting with a spiral pitch matching the optical inter-ring spacing (i.e., 6–7 µm). POM graph shows clearly alternating blue/orange color bands, with inter-ring space of ca. 6–7 µm. SEM graph on top surface of PEA films shows bulged rings as the ridge band, with the valley band submerged, and the inter-ring space being ca. 6–7 µm, in perfect agreement with the POM patterns. Nevertheless, what is underneath the valley or ridge bands on top surfaces of ring-banded PEA spherulites has remained unknown or highly debated in the past 60 years until 2012. The SEM micrograph onto the interior PEA bulk reveals clearly that the lamellae underneath the top surface of ring-banded spherulites are aligned in clearly layered structures resembling a corrugated board or an “onion-shell” structure as shown in Figure 2 below.
This work, based on newer approaches, proposes alternative mechanisms for understanding the origins of the ring-bands by showing the interiors of lamellae in spherulites with matched periodical lamellar structures and inter-ring spacing. Evidence supports that ring bands of alternating optical birefringence in polymer spherulites are packed by layered lamellae oriented in two nearly perpendicular angles (usually 60-90°, depending on geometry of crystal lattices of polymers), with their crystal axes differing sufficiently to give two sharply distinct birefringence colors in bands. The lamellae layer thickness, as revealed in interior SEM characterization, exactly matches the inter-ring spacing of optical bands in POM. Furthermore, interior dissection into ring-banded spherulites in bulk crystallized polymers does not reveal that the lamellae behave as single crystals and synchronize in spiral twisting in ordered
paces; rather, highly-branched polycrystalline lamellae fill the spherulites.

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