Программа экзамена кандидатского минимума по иностранному языку

1) Чтение и письменный перевод со словарем оригинального текста по специальности с английского языка на русский. Объем – 3 000 печатных знаков; время для подготовки – 1 час.

2) Просмотровое чтение оригинального текста по специальности на английском языке и передача содержания текста на английском языке (без словаря). Объем – 2 000 печатных знаков; время для подготовки – 10 мин.

3) Аудирование дважды прослушанного оригинального текста на английском языке по общей тематике факультета и устные ответы на вопросы по тексту (5-7 мин звучания).

4) Беседа на английском языке по тематике научных интересов аспиранта.

Пример текста для перевода

Recently, carbon-based organic semiconductors have drawn much attention due to their attractive application perspectives for flexible, lightweight, and environmentally friendly electronics. The most successful product so far is the organic light-emitting diode display with a multibillion U.S. dollar market, which are using doping by controlled coevaporation of small-molecule semiconductors and dopant molecules. The microscopy nature of doping in organic semiconductors is strongly different from inorganic semiconductors. One particularly relevant difference is that the dopant concentrations in organic are usually orders of magnitude higher than in inorganics to saturate the high level of deep traps in these materials. Consequently, one often ends in the so-called reserve regime, where doping efficiency is low.

Modulation doping is a widely used doping method in inorganic semiconductors where a heavily doped wide bandgap semiconductor is brought in contact with a narrow bandgap semiconductor. Efficient doping at the heterostructure interface is achieved by charge transfer from the wide bandgap semiconductor to the narrow bandgap semiconductor. The main advantage of this doping technique is the avoidance of ionized impurity scattering in the undoped narrow bandgap semiconductor. Hence, both carrier concentration and mobility can be independently maximized. Despite the wide use of modulation doping in high-frequency inorganic electronics, this doping technique has not been well studied and exploited in organic semiconductors. In particular, it has not been proven that higher doping efficiencies can be achieved. Furthermore, the proof-of-principle studies have not yet demonstrated improvements in devices or at least device-relevant parameters.

Organic materials could excel in thermoelectrics owing to their potential for low cost and large-area fabrication as well as their low thermal conductivity. They could provide a solution for powering small, autonomous devices such as flexible tags or could help to increase the energy efficiency of handheld devices, e.g., by harvesting the heat released from a mobile phone. Given their remarkably low thermal conductivity values, the thermoelectric power factor (S2σ) is the key figure of merit for optimizing organic thermoelectrics.

The electrical conductivity σ can be tuned by several orders of magnitude by doping; however, this also lowers the Seebeck coefficient as the chemical potential of the host-dopant system is reduced with increasing dopant concentration. Consequently, electrical conductivity and Seebeck coefficient need to be balanced to maximize the figure of merit ZT. The interplay between doping, charge carrier transport, and disorder in organic semiconductors, however, is a complex matter since the charge carrier mobility, the Seebeck coefficient, and the doping efficiency are connected to the degree of order/disorder in the system.

Пример текста на просмотровое чтение с передачей содержания без словаря

Alloying chemistry has been extensively developed as a versatile and effective means to integrate and synergize the physicochemical properties of different metals, and it has been used in various fields to improve material stability and performance. For example, Cu/Ag binary alloys show combined advantages of high strength and good conductivity, which have been widely used in the electric field. In addition to the remarkable success in engineering bulk metal materials, the prosperity of alloying chemistry has recently propagated into the nanoscale, where the ratio and spatial arrangement of hetero-metal atoms are critical to determining the electronic, optical, and catalytic properties of metal nanomaterials. In other words, determining the packing mode of different metal atoms in alloy materials plays an important role in customizing material properties. The packing mode of alloy materials is highly related to but different from the parent metal materials. Different metal elements show unique packing behaviors in forming bulk or nano-metal materials due to their distinct geometrical and electrical structures. Therefore, in the synthesis of alloy materials with a full composition spectrum, the packing mode evolution of hetero-metal atoms still remains mysterious. However, due to the inherent difficulties in producing plasmonic metal nanoparticles (>3 nm) with extremely high monodispersity, the underlying chemistry governing the alloying process of metal nanomaterials, especially for the structural evolution with composition change, has been rarely revealed.

In the past two decades, atomically precise metal nanoclusters (NCs) have been extensively studied in both basic chemical science and practical applications. Metal NCs are ultrasmall particles with a typical core size of <2 nm. Advances in cluster chemistry in the past two decades have allowed the synthesis of dozens of mono-, bi- and multi-metallic NCs with molecular purity, which make them descriptive with a molecular formula. The atomically precise structure of metal NCs together with their size-dependent molecular properties provides an ideal platform for revealing alloying chemistry at the molecular and atomic levels.

Пример текста на аудирование

LISTENING (5:45 min.)

QUESTIONS:

1)How do we measure light waves? What are bolometers used for in the first place?

2)What application of bolometers do the researchers suggest?

TRANSCRIPT

How do we measure light waves? Well, one way is to absorb the incoming radiation and turn it straight into an electrical signal. This is how digital camera sensors work, for example. But there's another way to go about it – heat. Bolometers heat up when they absorb the electromagnetic radiation in just the same way that you heat up when you're wearing a black t-shirt on a sunny summer's day. This heating up can then be measured, allowing these devices to assess how much light has been absorbed.

A bolometer basically is sensing the electromagnetic wave, the light, by measuring the temperature rise of the detector.

This is physicist Kin Chung Fong, author of a study out in this week's Nature. In fact, the study is just one of two papers out this week striving to build better bolometers. But we're getting ahead of ourselves. What are bolometers used for in the first place?

They are the working horse, actually, in many scientific experiments. For example, the temperature of the Universe is actually measured by bolometer. Today, we call it as a cosmic microwave background. That is the kind of landmark evidence of the Big Bang origin of our Universe.

Bolometers also come in handy for other scientific applications, such as the hunt for molecules in the atmospheres of other planets. But it's not all out of this world. Bolometers also come into their own for more down-to-Earth applications, like in construction. Researcher Mikko Möttönen has another application in mind, though. Mikko led the second of the two bolometer studies out in Nature this week, unrelated to Kin Chung's, and he's particularly interested in quantum computers. He's hoping that if bolometers became accurate and fast enough they could be used to carefully measure qubits – the building blocks of quantum computers.

A bolometer has never actually been used to measure these very tiny energy differences, and it is a very different way of doing the measurement than the existing system.

Okay, but how do you make a more sensitive bolometer? Well, since they rely on measuring a temperature rise from absorbing light, to some extent, you have two paths to go down. The first is to make a more sensitive thermometer to measure that heating up, but the second is to make the bolometer heat up more for a given amount of radiation. The trick to this is picking the right material, and this is where both teams had the same eureka moment – graphene. Graphene is a wonder material made up of carbon atoms arranged in a two-dimensional honeycomb lattice. That's right. It's 2D, meaning it's just one atom thick. Because of this, it has a minuscule volume and so should heat up hugely when it's absorbing radiation – perfect for a bolometer.

People have been, for decades, trying to make the bolometer smaller and smaller for higher and higher sensitivity. And there comes graphene, only one atom thick, and that could be one of the reasons that graphene could be a very good volumetric material…

That has a thickness of a single atomic layer, so it's the thinnest material you can have. And yeah, that really helped. It actually made the bolometer 100 times faster. It's now very promising to be used as a readout element for quantum computers.

Both teams are pretty pleased with the sensitivity of their new bolometers. Mikko compares his device's sensitivity to that of the first bolometer ever made by Samuel Pierpont Langley in the 1800s.

I mean, Langley was saying that he can observe with the bolometer, from one-quarter mile away that there's a cow on the field or not. And, in principle, our bolometer could easily do that if the cow was on the Moon.

Just to clarify, measuring a cow on the Moon is not the standard metric of a bolometer's skill. Plus, Mikko clarified that the Earth's atmosphere would also interfere with the measurement. And Kin Chung's team's device is also incredibly sensitive, reaching the theoretical physical limit for bolometer.

I still remember when I look at the data for the first time, I feel like wow, is it really true, we are reaching the fundamental limit that we cannot surpass anymore. Unless, of course, we can go to lower temperature, we can use a different material. But the basic strategy itself, we are hitting the fundamental limit.

For Mikko, his device is now sensitive and fast enough to potentially be incorporated into a quantum computer, something that he is eager to do.

This is an exciting moment and always in research you never know what the answer is before you've done it, so I think, we just try it out and see where we are.

Using bolometers in quantum computers wouldn't just be a breakthrough for these light-sensing devices. It could also allow for some additional flexibility in the design and operation of these computers. Kin Chung, on the other hand, is eager for some of the more research-driven applications of his team's devices, such as carefully measuring the fluctuations in the cosmic microwave background. Even though these two devices from the two teams use graphene as their secret weapon, there are still some subtle differences between the devices' designs. And far from feeling like it's stealing his thunder, Kin Chung is thrilled to see Mikko's parallel work on his graphene-based bolometer.

The temperature of the Universe is actually measured by bolometer. Today, we call it as a cosmic microwave background. That is the kind of landmark evidence of the Big Bang origin of our Universe. Bolometers also come in handy for other scientific applications, such as the hunt for molecules in the atmospheres of other planets. Bolometers also come into their own for more down-to-Earth applications, like in construction.

A bolometer has never actually been used to measure qubits – the building blocks of quantum computers. The task is to make the bolometer heat up more for a given amount of radiation. Graphene is a wonder material made up of carbon atoms arranged in a two-dimensional honeycomb lattice. Because of this, it has a minuscule volume and so should heat up hugely when it's absorbing radiation – perfect for a bolometer. It's now very promising to be used as a readout element for quantum computers. Both teams are pretty pleased with the sensitivity of their new bolometers. For Mikko, his device is now sensitive and fast enough to potentially be incorporated into a quantum computer, something that he is eager to do. Using bolometers in quantum computers wouldn't just be a breakthrough for these light-sensing devices. It could also allow for some additional flexibility in the design and operation of these computers. Kin Chung, on the other hand, is eager for some of the more research-driven applications of his team's devices, such as carefully measuring the fluctuations in the cosmic microwave background.

(Nature Podcast)