课程大纲
COURSE SYLLABUS

1.	课程代码/名称 **Course Code/Title**	**MSE5029/声子学与热超结构材料**
2.	课程性质 **Compulsory/Elective**	**Elective**
3.	课程学分/学时 **Course Credit/Hours**	**3/48**
4.	授课语言 **Teaching Language**	**English**
5.	授课教师 **Instructor(s)**	**Baowen LI**
6.	是否面向本科生开放 **Open to undergraduates or not**	**No**
7.	先修要求 **Pre-requisites**	（如面向本科生开放，请注明区分内容。 If the course is open to undergraduates, please indicate the difference.）

8. 教学目标
Course Objectives

（如面向本科生开放，请注明区分内容。 If the course is open to undergraduates, please indicate the difference.）

Phonons, the quantized lattice vibration, can transport in all solids. They are the main heat carriers in dielectric materials and semiconductors. Therefore, the control and management of phonons is of primary important for industrial application, like waste heat harvesting, heat dissipation and management of micro and nano electronic device, molecular electronic devices, quantum computer etc. More importantly, heat is a primary energy source for all living organisms. The understanding of the control mechanism might also help us get a clear picture of how living organism manage the heat energy inside.

However, controlling heat carried by phonons is not as easy as controlling electrons and photons, because phonons are not particles. Moreover, phonons do not have mass and charge that makes the control by external field like electric and magnetic fields much more complicated and challenging.

The phononics provides new approach on heat control. In this course, the underlying principle of thermal rectifier/diode, thermal transistor, thermal logic gates and thermal memory etc will be discussed. We will also discuss how to design thermal rectifier and other functional thermal devices.

9. 教学方法
Teaching Methods

（如面向本科生开放，请注明区分内容。 If the course is open to undergraduates, please indicate the difference.）

Direct lecturing will be the main method for this course, while project study and presentation will also be used for deeper understanding of the concepts. Both fundamental theories and applications will be covered in the course. Thermal metamaterials use existing natural materials to manipulate heat flux by changing its structures. The underlying principle is transforming invariance of the heat conduction equation. We will discuss several important functions and applications like thermal cloak, thermal concentrator, thermal lens, thermal camouflage, thermal inverter … Challenges and difficulties in

thermal cloak will be discussed. After the study of this course, the students shall be ready to start doing research in this very active field.

10. 教学内容
Course Contents
（如面向本科生开放，请注明区分内容。 If the course is open to undergraduates, please indicate the difference.）

Section 1	Phonons, anharmonic phonons, and thermal transport;
Section 2	Phononic Thermal Circuits: Active Control of heat flow via temperature bias
Section 3	Dynamical control of heat flux and beyond
Section 4	Heat control via phononic crystals
Section 5	Heat control through thermal metamaterials
Section 6	Thermal interfacial materials (TIM): controlling heat via interface
Section 7	Advanced topics of phononics
Section 8	Experimental methods for probing phonons and heat transfer due to phonons

11. 课程考核
Course Assessment

（①考核形式 Form of examination；②.分数构成 grading policy；③如面向本科生开放，请注明区分内容。If the course is open to undergraduates, please indicate the difference.）
There is no test. The students' scores will be based on:
(1) Midterm presentation (20%), 2-page-double-line report (20%),
(2) Final project presentation (20%) and final report (40%) (10-page, *Applied Physics Letters* style)**.**
The project will be based on a critical review of a topic of meta materials or a small research project). Students will survey the literatures and discuss with instructor about the selection of the topic. Once the topic is identified, the students are required to extensively review the topic in-depth. Students will need to provide critical comments on the papers, and present their view of what can be done better, or their own ideas on what to do next.

12. 教材及其它参考资料
Textbook and Supplementary Readings

1. N.- B Li et al, Phononics, *Rev. Mod. Phys* 84, 1045 (2012).
2. X Gu et al, Phononic thermal roperties of 2D materials, *Rev. Mod. Phys* 90, 041002 (2018).
3. Y Li et al " Transforming heat transfer with thermal metamaterials and devices", *Nat Rev. Mat* (2021)
4. C. Kittel, Introduction to Solid State Physics, 7th Ed., Wiley, 1996.
5. Lecture notes of this course will be published by Cambridge University Press as a textbook.