



## Bioplastics in Electronic Applications - NEC'S Perspective



Nano Electronics Research Laboratories  
NEC Corporation

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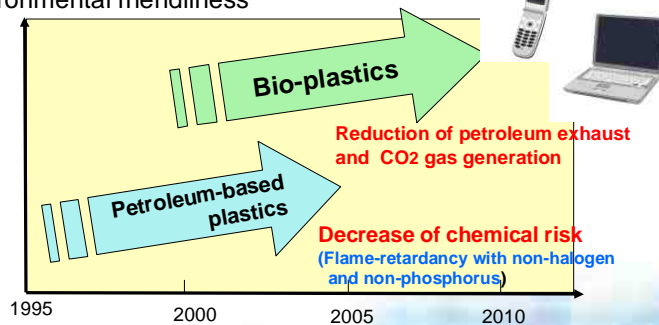
## Outline

1. NEC's environmental friendly plastic for electronic products
2. Use of bioplastics in Japan
  - Heat-resistant Kenaf-reinforced bioplastic
  - Flame-retarding bioplastic
  - Shape memory bioplastic
  - Heat-conductive bioplastic
3. Development of highly functional bioplastics by NEC
4. Conclusion

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### 1. NEC's Environmental Friendly Plastic for Electronic Products

Environmental friendliness

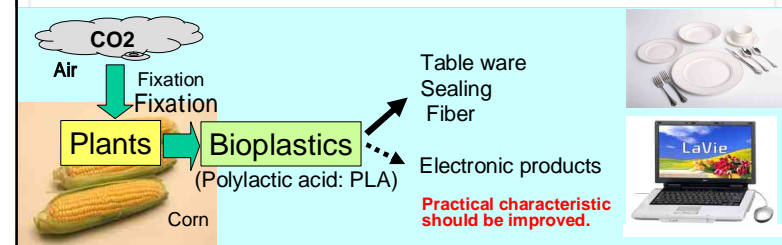


NEC aims high environmental friendliness of electronic products by using its **original eco-plastics**.

NEC Labs fundamentally develops original eco-plastics and then, collaborates with material producers in the mass-production.

### 2. Use of Bioplastics in Japan

- **Bioplastics** aid reduction of petroleum resource exhaust and CO2 gas causing global warming, and thus, get **high interests in Japan**.
- Bioplastic (Polylactic acid: **PLA**) has been begun to be used in electronic products, in addition to table ware, sealing, and fiber.
  - Merit**: Increase of environmental friendliness of products
  - Subject**: Improvement for practical characteristics **with keeping bio-mass content and safety**



## Resent Main News of Use of PLA in Electronic Products in Japan

2002 June: **Fujitsu** firstly started to use it in a part (IR mask) in PC

2002 Aug.: **Sony** used it in housing of "Walkman"



2004 Sep.: **NEC** used PLA/Kenaf composite in dummy cards in PC

2005 Jan. : **Fujitsu** used flame-retarding PLA composite (petroleum-based plastic alloy including phosphorus flame retardant) in PC housing



2006 March: **NEC** and NTT DoCoMo started the use of **PLA/Kenaf composite in ECO-cellular phone** (FOMA-N-701iECO)



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## 3. Development of highly functional bioplastics by NEC

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## NEC's Strategy of Development of Bioplastics (PLA composites) for Electronic Products

### Top level biomass-content, safety and performance

- 1) **Improvement of practical characteristics (heat resistance, strength, etc) of PLA by using biomass-based additives**
  - Developing a **heat resistant PLA/Kenaf composite** (biomass-content: 90%) and applying it to housing of cellular phone, etc.
- 2) **Increase of flame retardancy of PLA with safe flame retardant to expand its use to main electronic products**
  - Developing a **flame-retarding PLA composite** by using a metal hydroxide without halogen and phosphorus and applying it to housing in PCs, etc.
- 3) **Increase of performance of PLA by adding unique characteristics to create new products**
  - Developing a **shape memory PLA composite** and an **heat-conductive PLA composite** and applying it to new mobile products, etc

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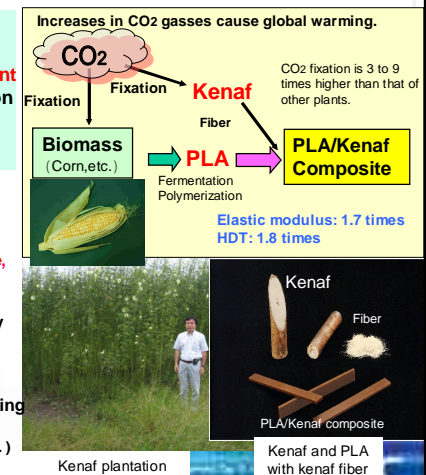
## (1) Heat resistant PLA / Kenaf Composite

### [ Accomplishment ]

Developing an highly **heat-resistant PLA composite** by the combination with kenaf fiber (Maintaining **high biomass ratio : 90%**)


### [ Technical Points ]

- a) The fiber of Kenaf (efficiently fixates CO<sub>2</sub>) increases PLA's **heat resistance, modulus and crystallization rate.**
- b) The **impact strength was improved** by adjusting the fiber length and adding a biomass-based flexibilizer
- c) The moldability was improved by adding a special crystallization promoter (Molding time: Less than 50 seconds/ 100°C.)



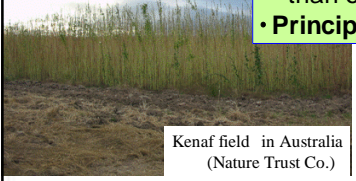


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## What is Kenaf ?



**Kenaf**

- **High ability to fixate CO<sub>2</sub>**  
Photosynthesis speed is 3-9 times faster than other usual plants
- **Principal use: textile, paper, animal food**

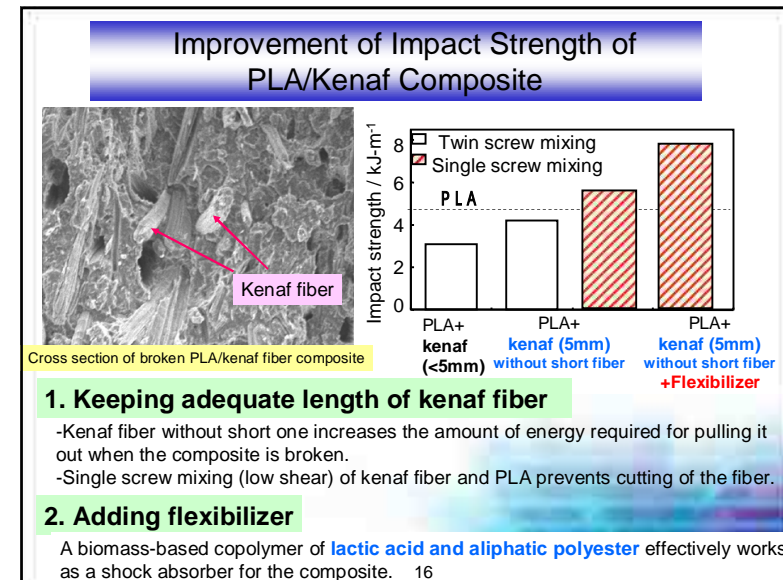
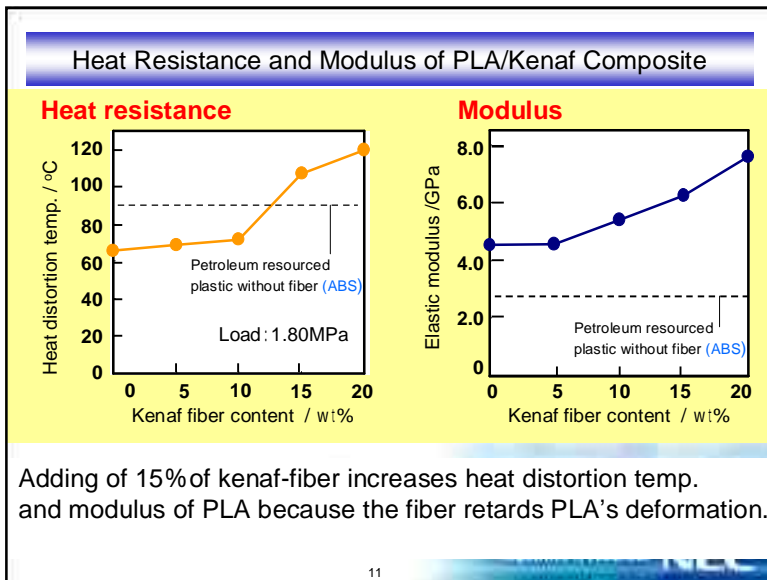
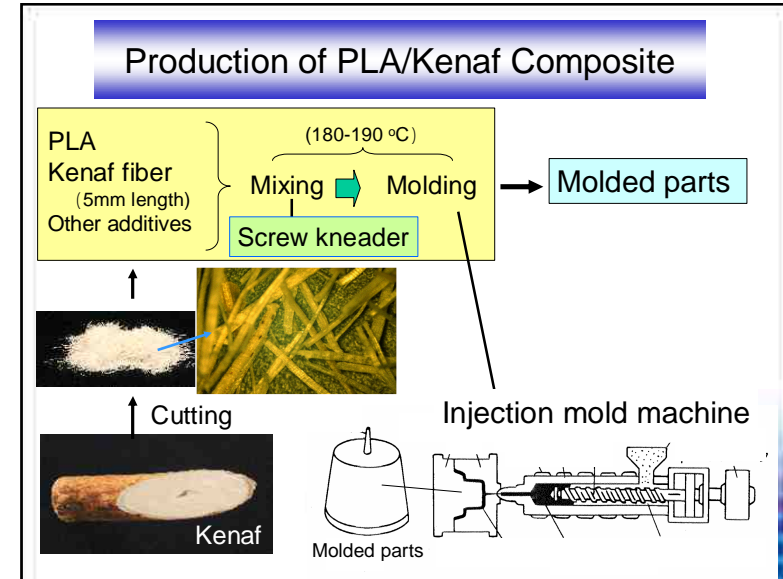




Kenaf field in Australia (Nature Trust Co.)

**Use of kenaf fiber as filler for plastics**

- **Previous studies**  
Compression molding for sheet application of automobile and building
- **NEC's development**  
Injection molding for parts and housing of electronic products

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## Characteristics of PLA/Kenaf Composite

	PLA	PLA/Kenaf * composite	Polycarbonate with glass fiber
Biomass-content (wt%) without inorganic components	100	90	0
DTUL (0.45MPa) (°C)	58	151	150
Impact strength (kJ/m <sup>2</sup> )	2.7	9.6	10.5
Flexural modulus (GPa)	3.4	4.9	3.1
Flexural strength (MPa)	108	86	93
Gravity (g/cm <sup>3</sup> )	1.27	1.30	1.27

\* Unitika LTD mass-producing

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## Practical Production and of PLA/Kenaf Composite and Using it in ECO-Cellular Phone



FOMA-N701iECO

Practical production of PLA/Kenaf composite (**Top level biomass:90%**) by the collaboration with **Unitika. LTD**

**First use** of bioplastic : PLA/Kenaf composite in casings of cellular phones by the collaboration with **NTT DoCoMo** (March,2006)

Expanding the use to other mobile products

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## (2) Flame-Retarding PLA Composite

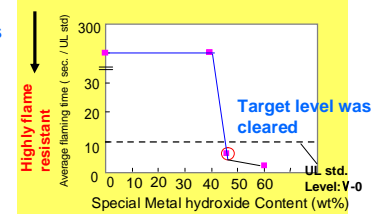
### [Accomplishment]

-Developing a **highly flame-retarding PLA composite** without toxic chemicals such as halogen and phosphorus to expand its use to main electronic products (PC, etc).

### [Technical Points]

- The PLA with a **metal hydroxide (a component of soil)** achieves **high flame retardancy (UL V0)** for the use in housing of electronics products such as PC, etc.
- Unique additives can recover other important characteristics, which are comparable to flame-retarding polycarbonate with GF.

### Effect of safe flame retardant (a metal hydroxide)



### Special Metal hydroxide

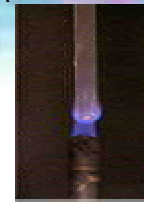


Absorbing heat during combustion

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## Flame-Retarding Behavior of PLA Composite

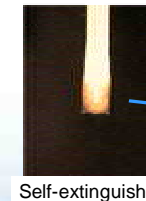
PLA



Ignition



Flame-retarding PLA composite



Self-extinguishing

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### (3) Shape Memory PLA Composite

**[ Accomplishment ]**  
 Development of a new intelligent bioplastic (PLA) performing shape memory and recycling (recyclable shape memory)

**[ Technical Points ]**

- Introducing thermo-reversible bonding in the structure of PLA provides it with shape memory and enables it to be recycled (re-molded).
- Application of the plastic in electronics creates new products

Free-style products, shapes of which are selected by consumers

**Recyclable Shape Memory**

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### Thermo-Reversible Cross-linked Structure of Shape Memory PLA Composite

**Thermo-reversible bond (Diels-Alder reaction)**

Heating  
Cooling

This bond dissociates to two functions by heating and these functions associated by cooling.

- Cross-linked PLA can perform shape memory.
- Dissociated PLA can be recycled.

**Thermo-reversible cross-linking structure**

Molecules of PLA

Heating at high temp.  
Cooling

Cross-linked PLA      Melted PLA

Shape memory      Recycling

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### Shape Memory and Recycling

Thermo-reversibly cross-linked PLA

Heat (60 °C) + Force

Heat (60 °C)

Melting and re-molding (160 °C) **Recycling**

Heat (60 °C) + Force

Heat (60 °C)

**Performing stable shape memory and recycling**

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### Free-style (Wearable) Mobile Products in Future Using Shape Memory PLA

**Favorite shape**

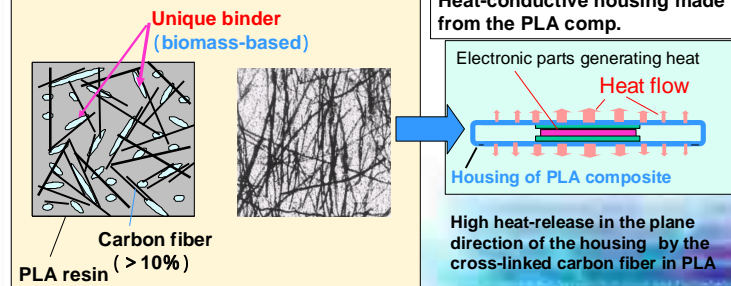
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## (4) Heat-Conductive PLA Composite

### [ Accomplishment ]

Creation of a **cross-linked structure of carbon fiber** in PLA achieves **high heat conductivity**, which improves heat-release issues caused by future small and thin sized electronic products (mobile phones, note-PCs, etc)

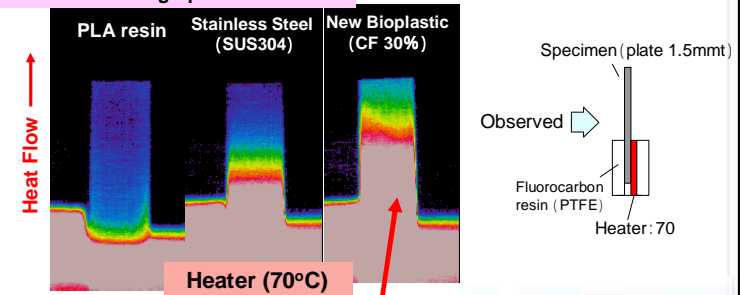
### Cross-linked structure of carbon fiber in PLA



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## Heat Diffusion of Heat-Conductive PLA Composites

### < Infrared Thermo-graph: After 30sec >



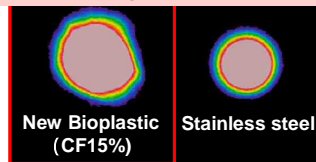
The heat diffusion ability of the new bioplastic composites:  
 With CF 10% : Comparable to stainless steel  
 With CF 30% : Twice more than Stainless

The densities (1.3-1.5) of the composites are less than half that of conventional thermally conductive plastics based on petroleum-resourced.

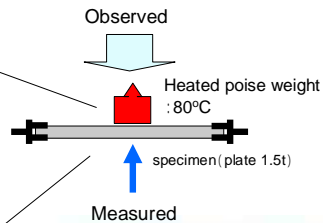
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## Heat Diffusion in Plane Direction of Heat Conductive PLA Composite

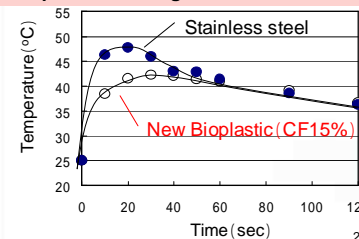
### Temperature change of the upper side (after 20sec)



### < Infrared Thermography >



### Temperature change of the reverse side



**After 20sec**  
 Stainless steel: 48 °C  
 New Bioplastic: 41°C

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## 4 Conclusion

-In Japan, electronics producers have begun to use bioplastic (PLA) in their products to increase the environmental friendliness.

-NEC developed an heat resistant **PLA/Kenaf composite** while keeping high biomass ratio and started to use it in housing of cellular phone from March 2006.

-To expand its use in electronic products, NEC has developed a **flame-retarding PLA** without toxic halogen and phosphorus and will start to use it in housing of PC, etc.

-Also, **new functional PLA composites performing shape memory and heat conductivity** have been developed for the use in future mobile electronic products.

-NEC will replace petroleum-resourced plastics in their electronic products to these bioplastics **more than 10% until 2010.**

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