ePIC SVT WP3 Electrical Interfaces Meeting

July 11, 2024

Experience and capabilities of LTU team in direction of creating sensitive layers based on thin bent MAPS chips

RPE LTU:
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Outline

- Brief introduction
- Considered initial data
- Features of approach proposed for ALICE ITS3
- ITS3 SpTAB prototypes based on ALPIDE MAPS chips
- Some test results for bent MAPS chips obtained by LTU team
- Conclusions

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Brief introduction

- LTU team performed some activities directed on development of interconnection approach to thin bent MAPS chips for ALICE ITS3 project (main part of following slides were reported by LTU team within ALICE ITS3 WP3 and/or WP4 meetings)
- Proposed interconnection approach is based on using ultralight adhesiveless aluminium-polyimide dielectrics and SpTAB interconnection technique
- Activities have been performed in 2020-2021 but, unfortunately, were postponed because of the russian invasion in Ukraine. Now the activities are resuming.
- Activities have been performed in close cooperation with colleagues from CERN and from University of Bergen (leading by Prof. Dieter Röhrich)

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Initial data for developing and proposing approach by LTU within ALICE ITS3 project

4

Considered information

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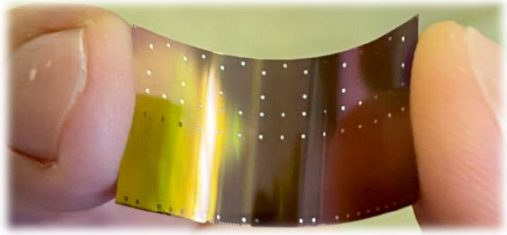
- LoI and Magnus' talks (ITS3 kick-of meeting 04.12.2019, *ITS plenary 21.01.2020)*



Note: all figures are from Magnus' talks

Base approach

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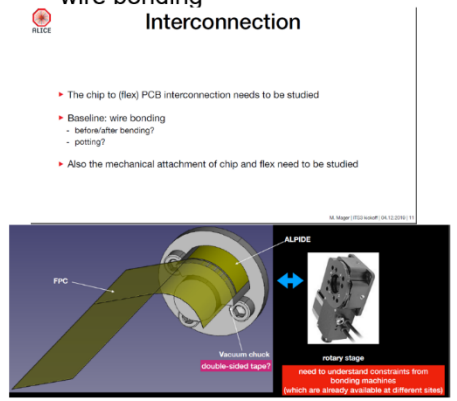
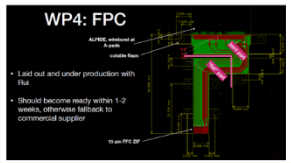
- Base line for interconnection: wire bonding



Note: all figures are from Magnus' talks

Features/possible complications (our feeling)

- Sensor need to be glued to FPC (or FPC-to-sensor) *- possible complication at further bending*
- Wire bonding on bent sensor- *special complicated jig agreed/tuned with/to wire bonder*
- Encapsulating of the wires for flat sensor- *possible complication at further bending*
- Encapsulating of the wires for bent sensor- *complicated process (liquid glues)*
- -…



Some features of proposed approach by LTU team

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Features of suggested approach

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- For connecting sensor-to-FPC chipcable is using
- Connecting chipcable to sensor and to FPC is performing in flat (unbent) shape
- Bending of functional assembly (sensor + chipcable + FPC) is foreseen
- Chipcable is bonding to the sensor, then to FPC
- Interconnection technique: ultrasonic bonding ribbon leads of chipcable (to sensor and to FPC)
- Chipcable (single layered) and FPC (multilayered) are made of adhesiveless aluminium-polyimide dielectrics
- Protecting bond joints - by dots of glue
- Functional electrical testing after each step
- Standard wedge wire bonding can be used (e.g. Delvotec)

Key steps of assembly work flow

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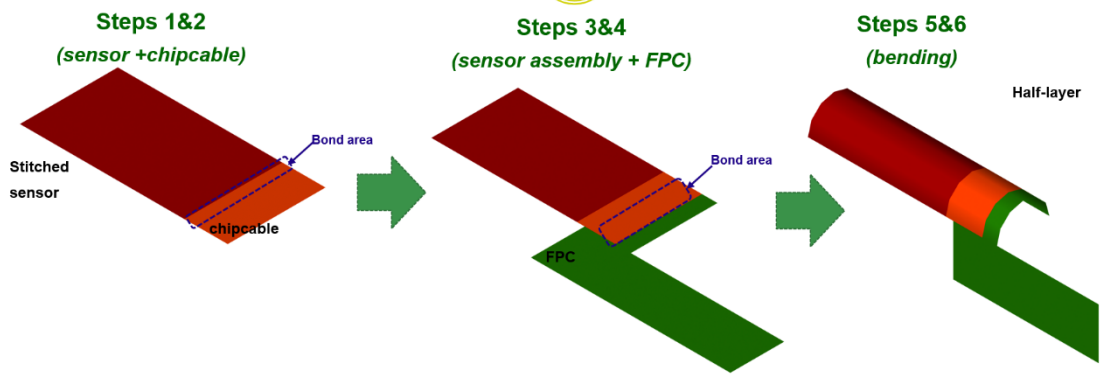

Note: after each step functional testing is performing!

ITS3 SpTAB prototypes developed and created by LTU team

Mechanical mock-up of bent chip

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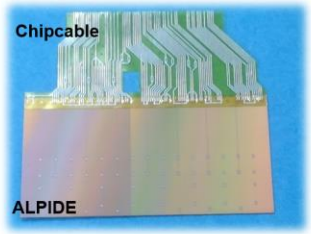

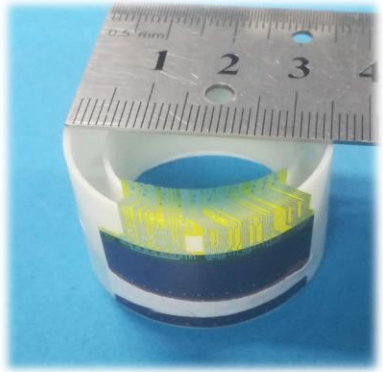

- Bending radius is 18 mm (ITS3 layer 0)
- For the mock-up pCT/FoCal chipcable has been used (Al 14um thick)
- Assembly was bent/unbent few times – damages of bonds were not observed (visual inspection)

January 31, 2020, CERN viatcheslav.borshchov@cern.ch, ihor.tymchuk@cern.ch

Composition of the prototype: assemblies

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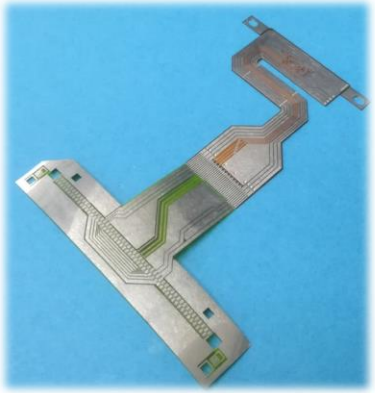
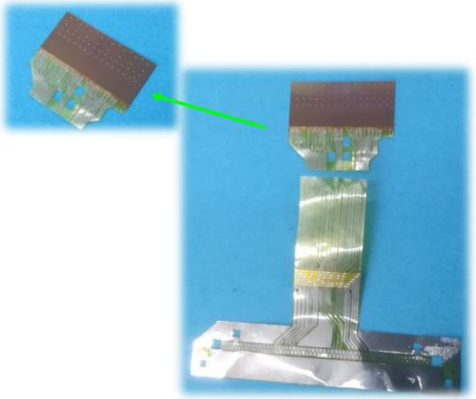
Multilayered flex



Chipcable assembly



SMDs on FlexMounts

ITS3 WP4 meeting, October 02, 2020 viatcheslav.borshchov@cern.ch, ihor.tymchuk@cern.ch

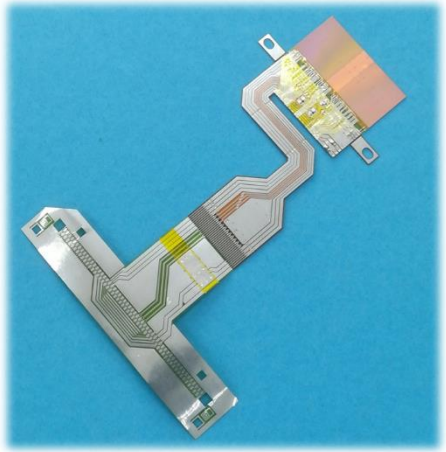
ITS3 SpTAB interconnection prototype

7

ITS3 SpTAB interconnection prototype (v01): flat shape

8

Prototype



Prototype with test frame

Prototype in PTB

ITS3 WP4 meeting, October 02, 2020 viatcheslav.borshchov@cern.ch, ihor.tymchuk@cern.ch

ITS3 SpTAB interconnection prototype (v01): bent shape

9

Prototype (on metal core)

Prototype with test frame in PTB

ITS3 WP4 meeting, October 02, 2020 viatcheslav.borshchov@cern.ch, ihor.tymchuk@cern.ch

Important notes:

- **PTBv01 hardware and software have been used for all tests of ALPIDE chips**
- **PTBv01 developed, created and kindly provided to LTU by UniBergen team (leading by Prof. Dieter Röhrich) within joint activities within pCT project/collaboration**

ITS3 SpTAB chipcable assembly and the first test results for bent MAPS chip

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ITS3 SpTAB chipcable assembly (v01): flat&bent shape

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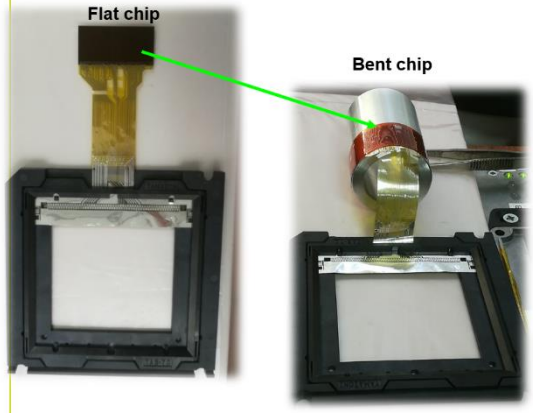
Assembly with test frame

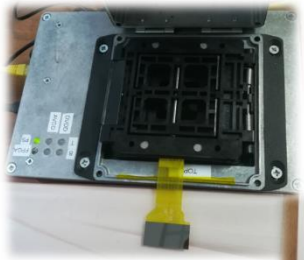
Flat chip

Bent chip



Assembly in PTB

Flat chip



Bent chip

Note: used ALPIDE is T847786W02R41 (NOK according to ALICE ITS Data Base)

Test results of chipcable assembly (PTB v01)

7

Test	flat	bent	flat	bent	flat
Power test	OK (BRONZE)	OK (BRONZE)	OK (BRONZE)	OK (BRONZE)	OK (BRONZE)
Register test	OK (GOLD)	OK (GOLD)	OK (GOLD)	OK (GOLD)	OK (GOLD)
High speed links test	OK (GOLD)	OK (GOLD)	OK (GOLD)	OK (GOLD)	OK (GOLD)
FIFO test	OK (GOLD)	OK (GOLD)	OK (GOLD)	OK (GOLD)	OK (GOLD)
Visual inspection (chip and chipcable)	No visible damages, cracks	No visible damages, cracks	No visible damages, cracks	No visible damages, cracks	No visible damages, cracks

Further test results for bent MAPS

Testing approach

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Steps

1. flat chip (1f) ⇨ 2. bent chip (2b) ⇨ • • • ⇨ 19. flat chip (19f) ⇨ 20. bent chip (20b) ⇨ 21. flat chip (21f) • • •

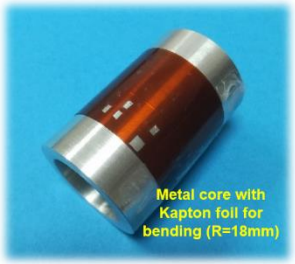
Test equipment: PTB v01

- ✓ *Power test*
- ✓ *Register test*
- ✓ *High Speed links test*
- ✓ *FIFO test*

Important: *pixel matrix is not testing*

Visual inspection after each step is performing also

Radius of bending during bending tests is 18 mm



Note:

➢ *PTB is developed and produced by UiB team and kindly provided to LTU*

Test results of chipcable assembly (PTB v01)

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Test \ Step	1 f	2 b	3 f	4 b	5 f	6 b	7 f	8 b	9 f	10 b	11 f	12 b	13 f	14 b	15 f	16 b	17 f	18 b	19 f	20 b	21 f
Power test	OK G	OK B	OK S	OK B	OK S	OK S	OK S	OK G	OK G	OK G	OK G	OK G	OK G	OK G	OK G	OK G	OK G	OK G	OK G	OK G	OK G
Register test	OK G	OK G	OK G	OK G	OK G	OK G	OK G	OK G	OK G	OK G	OK G	OK G	OK G	OK G	OK G	OK G	OK G	OK G	OK G	OK G	OK G
High speed links test	OK G	OK G	OK G	OK G	OK G	OK G	OK G	OK G	OK G	OK G	OK G	OK G	OK G	OK G	OK G	OK G	OK G	OK G	OK G	OK G	OK G
FIFO test	OK G	OK G	OK G	OK G	OK G	OK G	OK G	OK G	OK G	OK G	OK G	OK G	OK G	OK G	OK G	OK G	OK G	OK G	OK G	OK G	OK G
Visual inspection	No visible damages or cracks on chip, cable and bond joints																				

Preliminary conclusion:

Any significant differences have not been observed for 10 bent/unbent steps

(without tests of pixel matrix)

Notes G - Gold, S - Silver, B - Bronze

Parameter	Category: gold	silver	bronze	NOK
I_A (mA)	10.42 to 15.54	10.42 to 15.54	10.42 to 15.54	otherwise
I_D (mA)	44.40 to 50.02	40.00 to 50.70	35.00 to 70.00	otherwise

ITS3 SpTAB chipcable assembly: improved and developed test approach

Object and options of bending tests

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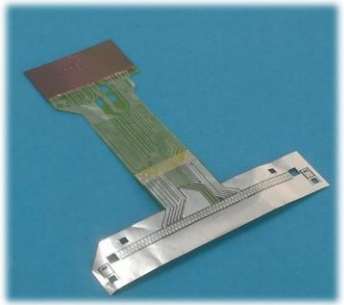
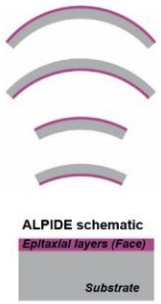
Object:
ITS3 SpTAB chipcable assembly



Bending options:



- **30FU** (along 30mm side, Face Up)
- **30FD** (along 30mm side, Face Down)
- **15FU** (along 15mm side, Face Up)
- **15FD** (along 15mm side, Face Down)

ALPIDE schematic

Bending test options sequence:
30FD-30FU-15FD-15FU

Notes:
- for bending plexiglass core (R=18mm) with Kapton foil is using
- *testing is performing for covered chip*

Used ALPIDE chip is T847786W04R26 (OK /BRONZE according to ALICE ITS Data Base)

Chipcable assembly bent in different options

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Test results for 30 FU and 30 FD options

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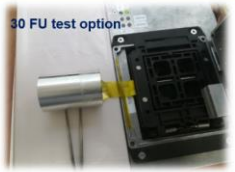
Option	Step / Test	1 f	2 b	3 f	4 b	5 f	6 b	7 f	8 b	9 f	10 b	11 f
30 FU (tested earlier)	Power test	OK/G	OK/B	OK/S	OK/B	OK/S	OK/S	OK/S	OK/G	OK/G	OK/G	OK/G
	Register test	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G
	HS links test	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G
	FIFO test	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G
	Visual inspection	*No visible damages or cracks on chip, cable and bond joints*										
30 FD	Power test	OK/G	OK/G	OK/G	OK/S	OK/G	OK/S	OK/G	OK/G	OK/G	OK/G	OK/G
	Register test	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G
	HS links test	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G
	FIFO test	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G
	Visual inspection	*No visible damages or cracks on chip, cable and bond joints*										

G – Gold, S – Silver, B - Bronze

30 FU test option



30 FD test option

Conclusion:

Any significant differences have not been observed for 11 bent/unbent steps for FU and FD test options (without analog scan of pixel matrix)

Test results for 15 FU and 15 FD options

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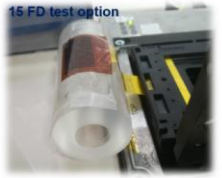
Option	Step / Test	1 f	2 b	3 f	4 b	5 f	6 b	7 f	8 b	9 f	10 b	11 f
15 FU	Power test	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G
	Register test	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G
	HS links test	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G
	FIFO test	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G
	Visual inspection	*No visible damages or cracks on chip, cable and bond joints*										
15 FD	Power test	OK/G	OK/G	OK/G	OK/S	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G
	Register test	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G
	HS links test	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G
	FIFO test	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G	OK/G
	Visual inspection	*No visible damages or cracks on chip, cable and bond joints*										

G – Gold, S – Silver, B - Bronze

15 FU test option

15 FD test option



Conclusion:

Any significant differences have not been observed for 11 bent/unbent steps for FU and FD test options (without analog scan of pixel matrix)

Obtained test results for Id and Ia for ITS3 SpTAB chipcable assembly

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Difference in Ia for flat/bent ALPIDE for 30 FU & 30FD options

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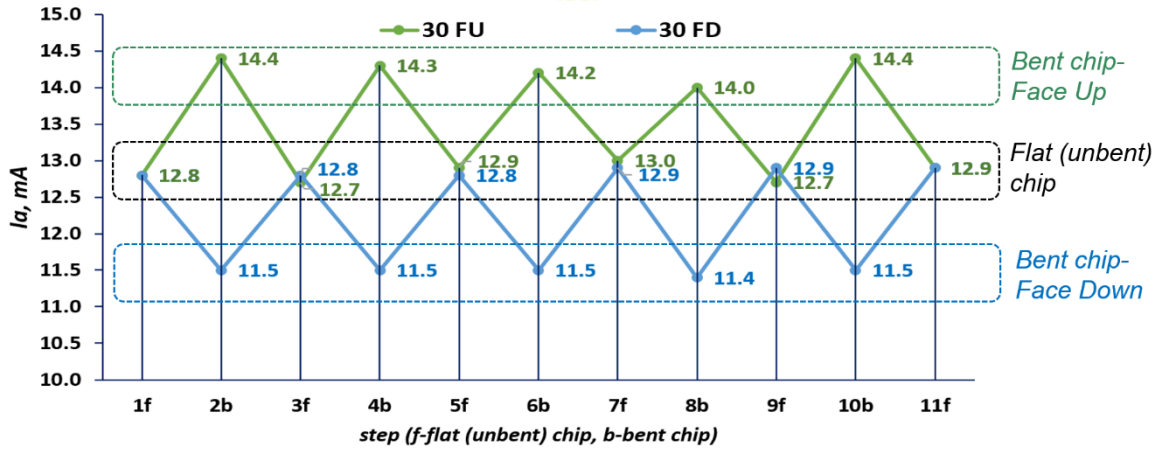

Observed difference of Ia value: FU option - up to ~1,5mA *higher*, FD option – up to ~1,5mA lower

Difference in Ia for flat/bent ALPIDE for 15 FU & 15FD options

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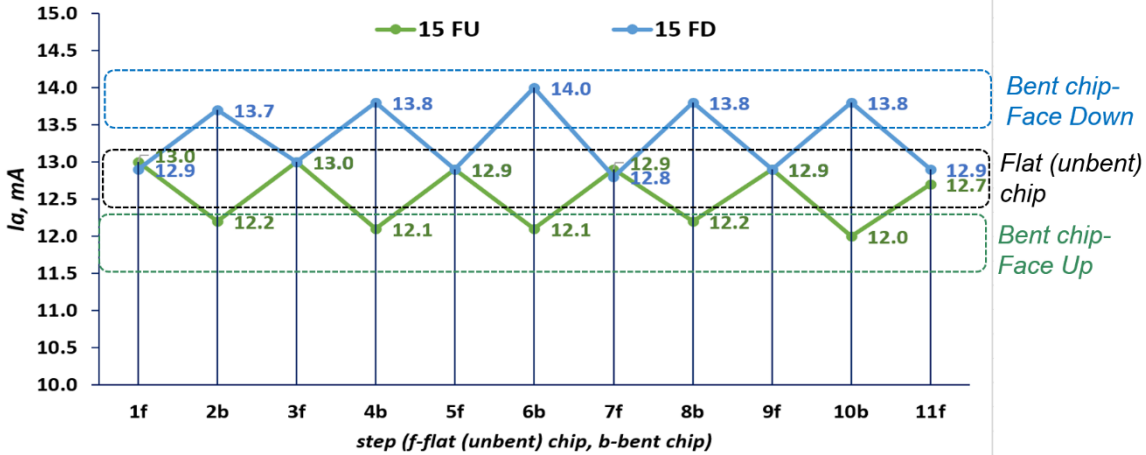

Observed difference of Ia value: FU option - up to ~1,0mA lower, FD option – up to ~1,0mA higher

Conclusions

- LTU team has successful experience in activities relating interconnecting thin bent MAPS chips within ALICE ITS3 project (in close cooperation with CERN and University of Bergen teams)
- Available experience, approaches and capabilities of LTU team might be developed and implemented in further activities relating bent MAPS chips for ePIC SVT project

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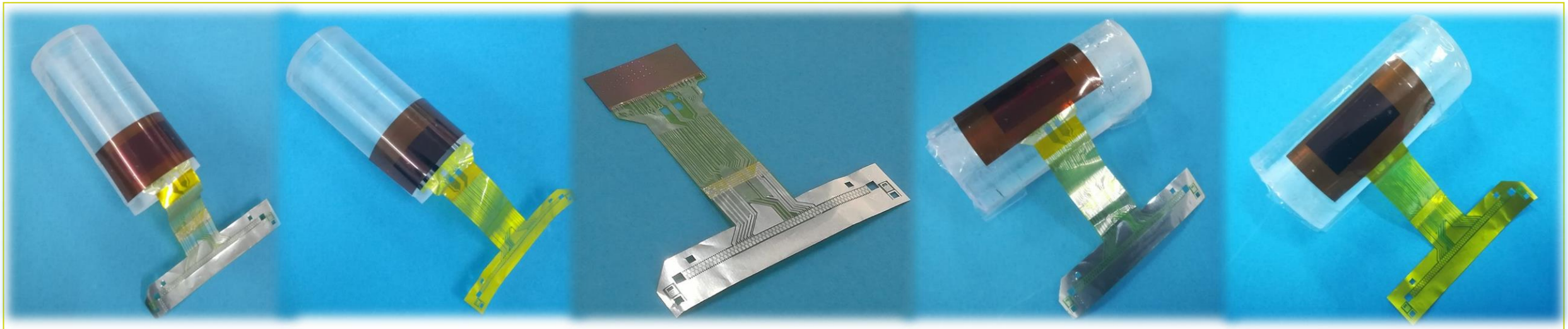
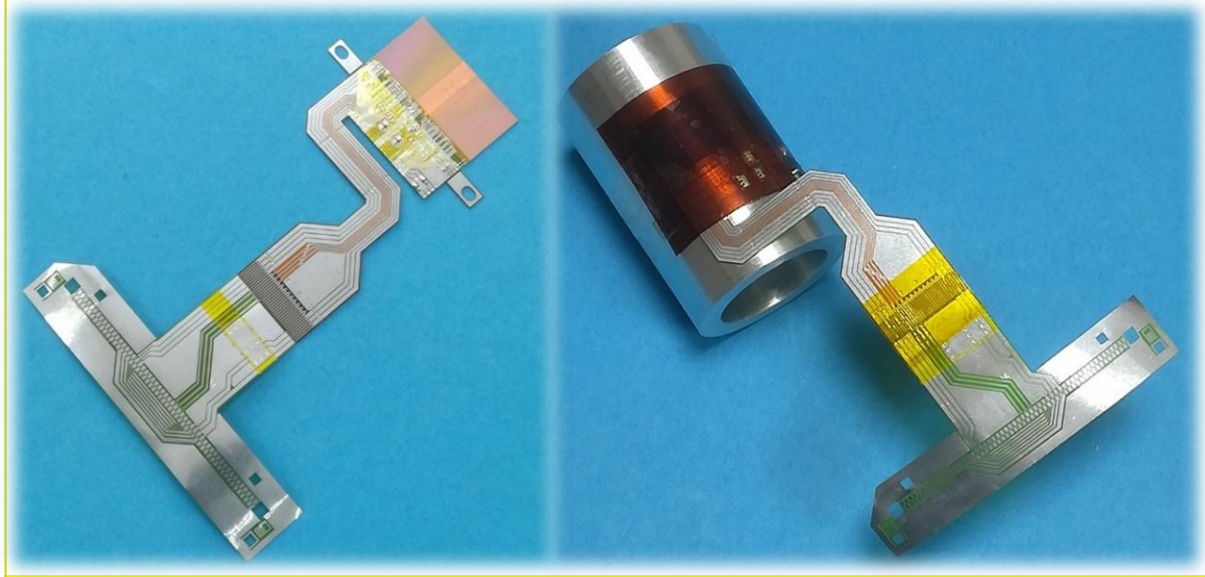


Thanks a lot for your attention!



With the best wishes
from Ukraine!